PREFATORY NOTICE.

During the progress of an extended and systematic survey like that which is now being carried out by the Geological Survey of India, it necessarily happens that information is obtained regarding districts, or minerals, or fossils, which, though imperfect, is still of much value, and which forms a link in the chain of evidence tending to establish the age or character of the several groups of rocks or formations in this country. It has hitherto been impossible to give these isolated facts publicity, as it would obviously be inconsistent with the scheme of the 'Memoirs of the Geological Survey of India' to publish in them detached facts, or minor sketches, only in anticipation of the more finished and detailed descriptions which it would be practicable to give a little later. In several cases, however, to wait for this more full and complete description would be tantamount to waiting for many years. The area of the Indian Empire is so immense, the staff of the survey so limited, that the detailed work of each successive season makes but a very small inroad on the country yet unvisited; while the almost total ignorance of the geological structure of India under which we suffered until within the last few years made it both difficult to anticipate the importance of such isolated observations and impossible to attempt to reduce them to any general system.

The conditions of the case, however, appear to me now to have undergone sufficient alteration to justify, and even to demand, a more rapid publication of such facts, though they may be isolated and imperfect. There are also many other matters, essentially forming a portion of the labors and of the progress of the survey, of which the public may fairly, as I think, expect a knowledge up to the latest practicable date.

It is therefore contemplated to issue independently of the "Memoirs of the Geological Survey of India," and of the "Palæontologia Indica," a separate series which shall bear to these Memoirs somewhat the same relation which in learned societies, the 'Proceedings,' 'Sitzungsberichte,' 'Monatsberichte,' 'Bulletins,' &c., do to the larger and more important 'Transactions,' 'Memoirs,' 'Abhandlungen' 'Denkschriften,' &c. This series will contain a notice of the current work of the survey up to date; a list of contributions to the Museum or Library; a list, and occasionally an analysis, of such books published elsewhere

as bear upon Indian Geology; and, generally, of all facts illustrating the immediate object of our researches, which may from time to time come to our knowledge.

This series will be issued of the same size and general form as the 'Memoirs,' so that it may finally be bound with them, forming a second part of each volume. It will be paged separately, and printed economically so as to be saleable at a very low price; excepting in special cases, it will not contain any illustrations, which in this country are always a source of great delay and cost, and so far as practicable, a part of this series will be issued at intervals of three months. These parts will vary in size as the matter available may vary, but within certain limits the portion referring to each year will be kept nearly of the same extent.

The present is the first issue of these 'Records,' and must be looked upon as an experiment, which will only be continued in the event of its being found really useful.

T. OLDHAM,

Supdt., Geol. Survey of India.

CALCUTTA, *June* 1868.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 1.] 1868 [June

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1867.

The adoption of the ordinary calendar year, from the 1st of January to the 31st of December, as the period to which the annual reports of the Geological Survey of India should in future refer, while the report of last year extended to the close of the financial year, or the 31st of March 1867, necessarily restricts the present report to only nine months out of the twelve. For convenience, however, it may be desirable to consider it as including the three months at the commencement of the year also.

During the past season, the number of the officers of the Geological Survey actually at work has been considerably reduced, by absence on leave, and by other causes. At the commencement of the season Mr. Wynne was still absent on medical certificate, and only rejoined on the expiry of his leave towards the end of the year. Mr. W. Theobald left India on furlough after a continuous and useful service of eighteen years without absence, and he has not yet returned. Mr. F. Fedden obtained six months' leave, and being delayed in rejoining by stress of weather, has since obtained one month's further leave, rejoining at the beginning of December. Mr. R. B. Foote was compelled by ill health to leave rather suddenly in May last, and is still absent. Mr. Tween also, who was in charge of the Museum in Calcutta, was compelled to leave on medical certificate, and is still absent.

Further, Mr. W. T. Blanford was appointed to accompany the Abyssinian Expedition as Naturalist and Geologist. And Mr. H. M. Ormsby officiated as Professor of Physical Science at the Presidency College for six months, during the temporary absence of the Professor.

The working staff has, therefore, been much fewer in number than usual, and the progress made in the geological examination of the country has been proportionally curtailed.

Taking advantage of this reduction of numbers, and the comparatively lighter amount of work in the office, and very desirous of obtaining for the labors of the Geological Survey in India the vast advantages which must always result from an actual comparison of specimens and from the study of such original series as can never be hoped for in this country, I obtained authority to proceed to Europe for a few months during which the climatal conditions of this country prevent the possibility of field-work being carried on. Taking with me Dr. Ferd. Stoliczka, Palæontologist to the Survey, we accomplished much, and returned to India at the beginning of December.

With these few preliminary remarks, showing the diminished strength of establishment with which the Geological Survey has been working during the past year, I shall notice in the usual order the progress made.

Bengal and Upper Provinces.—In the last report I briefly noticed the reconnoissance of the country lying south of the districts which were under detailed examination near Raniguni and Hazareebagh, and extending westwards to the south of the Rewah country, including a large portion of the great drainage basin of the Mahanuddi. Proceeding from Ramghur to Ranchi, and thence to Pertabgurh, Mr. Medlicott found the greater part of the road to extend over the undulating highland region of Chota Nagpore. About 30 miles east of Pertabgurh,

there is a decided ghât or sudden descent into the wide valley of the Mohun, where the far stretching view over the low plains at once suggests a change in the nature of the rocks; there, in fact, comes in a portion of the great central area of the rocks associated with the coal-bearing series of India. The road itself, excepting in one or two spots where the newer formations still exist, runs upon crystalline rocks, keeping to the north side of the Mohun valley; although west-wards from Burwah, the upper members of these newer formations had been noticed capping some of the hills of the upland area, in one case themselves capped by trap.

These rocks extend from Pertabgurh to the Husdoo, through Bisrampur (60 miles), here and there varied by a tongue-like extension of the crystalline rocks, forming prolongations in most cases of hills lying to the eastward. Many of these hills by their outline show that the crystalline rocks extend to their summit, while others form table-lands, on the scarped edges of which the white sandstone is conspicuous. These scarps admirably exhibit the very unequal surface of deposition on which the sandstones were formed. From the Husdoo and the plains of Belaspur, the main mass of the crystalline rocks, which greatly predominate, lies to the north-west, forming the hilly region of Mahtin, while the numerous and almost detached areas of the secondary rocks (chiefly of the Talcheer series) are extensions from the eastwards, where the table-topped hills of Odeypur appear to be formed altogether of the sandstones. With this extension of that series of rocks is connected the small coal basin of Koorbah. On the Mahtin hills themselves a few remnants of the upper sandstones stand up like old fortresses on the highest summits.

Over the area lying between the Koorbah coal-basin and the plains of Belaspur, there is no continuous high ground. Isolated ridges, mostly of inconsiderable elevation and composed of the crystalline rocks, occur.

In this region of the Mahanuddi, as also in that of the Godavery drainage basin, the only knowledge we had of the structure of the country was derived from the Revd. Mr. Hislop's exertions; he had, however, confounded rocks belonging to two distinct series, between the deposition of which there had been an immense interval of time. The great plains of Chutteesghur were colored as belonging to the same series as the coal-field of Koorbah. In reality, however, the rocks belong to that very much older series to which the general name of Vindhyan has been given. These cover an area of more than 12,000 square miles, limestone being the prevalent rock. On the north, they abut against the crystalline rocks; on the west, they pass under the Deccan traps; to the south-west, they stretch to an unknown (as yet) distance up the valley of the Mahanuddi; to the south-east, they rest upon crystalline rocks; and to the east, they are crushed up with, and upon, similar rocks in a complicated manner. The more recent Talcheer rocks are filled with debris from these, but nowhere was the actual contact or superposition visible.

The Talcheer rocks extend from the Odeypur district to very near Sumbulpur. The country towards Gangpur from Chaibassa is now being examined in detail, so that it need not be more specially alluded to here. At Chaibassa itself there is the junction of the newer submetamorphic with the gneissose rocks. There is also a grand exhibition of trappean intrusions, which, it is noteworthy, occur with vastly greater frequency in the granites than in the slates.

This extended reconnoissance of Mr. Medlicott's will prove of very great value when we are able to extend our detailed researches into this vast area.

The Hoharo or Karunpoora coal-field was completed in the early part of the year by Mr. Hughes. This, as stated in my report for last year, is of considerable extent, covering an area of not less than five hundred square miles, but it is poor in coal, few of the seams promising well. Iron is largely smelted within this area, nearly 200 small native furnaces being still at work. Later in the season Mr. Hughes completed the examination of the South Karunpoora coal-field, also of considerable superficial area, and at the same time richer in coal.

We have unfortunately been unable to obtain maps so as to enable us to continue and complete the examination of the coal-field of Palamow, lying to the west of those just alluded to. We had commenced this last year, and in full hopes of being able to proceed steadily to the completion of its examination. It is highly important to obtain some trustworthy information regarding the prospects of good fuel being discovered there, especially in connection with the proposed execution of the Soane canals. As soon as maps are available, the geological examination of the field will not take long.

The smaller and comparatively valueless field near Eetcoora has subsequently engaged Mr. Hughes' attention, and it will be quite completed before the present season is over.

Last year I noticed the serious interruption to the continuity of our work in Manbhoom caused by the maps not being ready for issue. To prevent a similar stoppage during the present season, I obtained, at considerable expense, tracings of all the maps required to complete the area, and join on to the Topographical Survey work to the south. Since the early part of the year, therefore, Mr. V. Ball has been engaged in the Manbhoom country, steadily carrying his geological lines southwards: while Mr. Ormsby has been carrying the boundaries in the adjoining country to the south and to the west, and near Ranchi. Mr. Ball appears to have established some interesting facts as to the connection of special groups of rocks with certain kinds of mineral wealth.

Mr. Mallet has been engaged principally in the neighbourhood of Jhansi and Lullutpore, tracing out the geological boundaries in the country included in the northern portion of Sheet 70 of the Indian Atlas. Mr. Hackett similarly has been steadily carrying his geological lines southwards from the Gwalior country, using as the basis of his researches the admirable maps of the Gwalior and Central India Topographical Survey.

Mr. Wilson is similarly engaged in a detailed examination of the Saugor district, and of the country lying between that and Jubbulpore. This had been very cursorily visited before, but when no maps existed: now we have the excellent maps recently issued of these districts.

Mr. Blanford's labors during the few months at the beginning of the year have been briefly noticed in last year's report. Subsequently to that, he progressed steadily to the south, and carried his lines of boundary down to the Chanda coal, where he examined the field, and ascertained the probable extent of the coal-bearing rocks in that neighbourhood, which is not great. A preliminary report on the coals of this field was submitted shortly after. It is probable that a large proportion of the rocks near Chanda belong to the same series as those in the immediate neighbourhood of Nagpur, which in my last report I stated had been recognized as possibly belonging to a different series. This inference has not been altogether borne out by subsequent and closer investigation, although the necessity for separating the rocks into a distinct group of the Damuda series has been fully established. The full details have still to be worked out.

Mr. Blanford has since then been deputed to accompany the Abyssinian Expedition as Naturalist and Geologist, and has joined the forces from Bombay. This is a duty for which he is singularly well qualified, and I feel perfectly confident the results will amply justify the wisdom of the selection.

Bombay.—Mr. Fedden has been absent on leave for seven months of the year. On his return, he has been deputed to join Mr. Wynne in Cutch. Mr. Wynne has been placed in charge of the Bombay party, in consequence of Mr. W. Blanford's absence in Abyssinia, and aided by Mr. Fedden, he has taken up the detailed examination of Cutch.

Madras.—The labours of the Madras party have been curtailed by the absence, as already alluded to, of Mr. Foote. In my last report I expressed a hope that the close of the season would see the examination of the Kuddapah rocks carried up to the limit of Sheet 76 of the Indian Atlas. This was accomplished in one place; but illness in camp and inclemency of the season prevented the whole breadth being examined so far north. A general reconnoissance to the north of the Kistna has shown that these sub-metamorphic rocks stop out, for a distance at least, a few miles north of the Kistna, the gneissose rocks appearing from beneath them, all across from the vicinity of Juggiapett round by Warupully to Kurnool. Of the portion that now remains to be mapped in, a large area is marked on the maps as an inaccessible tract unsurveyed. Across this there are only one or two footpaths at considerable intervals. And seeing the nature of the ground and the great intricacy of the geological lines, I greatly fear that with only two assistants at work it will be impossible to get over all this area this season. It is certain, however, that a general knowledge of its structure will be obtained.

Of the Madras work two further quarter sheets, Sheet 78. NE. and SE., have been sent to the engraver months since.

Burmah.—I have already in my last report detailed the progress of the work in Burmah for the few months at the commencement of the year. Mr. Theobald left, on furlough, in

April, and is still absent, and it has not been practicable to send any one to take up his work this season. On his return in the autumn, Mr. Theobald will resume his researches in Burmah.

PUBLICATIONS.—During the year the Survey has issued of the *Memoirs of the Geological Survey of India*, the following:—"On the neighbourhood of Lynyan in Sind," where coal was said to occur: "On the Geology of a part of Cutch," where also coal was stated to have been worked; both by Mr. W. T. Blanford. There have also been issued a detailed report on the Bokaro coal-field in the Hazareebagh district, by Mr. T. W. Hughes, and a similar one on the Ramgurh coal-field by Mr. V. Ball. Also a general sketch report on the trap rocks of Western and Central India, by Mr. W. T. Blanford.

In Sind, the coal at Lynyan, which had been the subject of many reports extending over several years, and of considerable expenditure of time and money, proved to be merely a nest or patch of lignite, not extending one hundred yards in any direction. Nor did there appear any probability of other deposits occurring in the vicinity. In Cutch, the only seam of coal seen is a little more than one foot in thickness, of which thickness only about eight inches is fairly good. It is, therefore, obviously not worth working. Mr. Blanford's visit being, unavoidably at the time, a very cursory one, a careful examination of the whole of Cutch has this year been commenced and the results will be of high interest. This coal of Cutch is geologically of a middle jurassic age, while the lignitic coal of Sind belongs to the lower tertiary epoch. The Bokaro and Ramgurh coal-fields belong to the ordinary coal-bearing series (the Damuda) of Indian rocks. They lie to the south of Hazareebagh, and are of considerable extent, but not rich in coal. And, as I have already stated, must I think be looked upon as only useful to meet a local and limited demand, and this, too, only for such rougher work as the inferior quality of coal may be adapted for. Mr. Blanford's report "On the traps of Western and Central India," throws light on their history, extent and character, and on their geological epoch. Mr. Blanford thinks it highly probable that the commencement of these great over-flowings of lava which extend over such an immense area may have occurred even so early as the time of the middle cretaceous period, and have continued up into tertiary ages. These conclusions, however, are based upon evidence, which Mr. Blanford himself admits to be far from conclusive. More detailed examinations must be carried out before they be admitted. The subject is one of great interest in Indian geology.

In accordance with a demand from the Right Hon'ble the Secretary of State for India, I prepared at the commencement of the year a brief summary statement of all that was known regarding the coal-fields of India. Details, as full as the information obtainable admitted of, were given "of the resources and production of coal." During the years from 1858 to 1866, inclusive, these returns showed an actual increase in the amount of coal raised in India, from $61\frac{1}{2}$ lakhs of maunds to $108\frac{1}{2}$ lakhs. The returns were avowedly only careful approximations, as there was no organization for the compilation of such information, but they are probably relatively correct. Arrangements have been made to carry on these statistics of out-turn of coal, so far as the information can be obtained.

A new edition of the Catalogue of Meteorites in the Geological Survey Musuem, has also been issued embodying many more recent acquisitions in Europe. In it are recorded 152 stones, and 95 iron aerolites. These if taken in conjunction with seven others, of which the Geological Museum, has no specimen, but which are represented in the Indian Museum, will form a total number of two hundred and fifty-four distinct falls, represented in Calcutta: a number which fully justifies the statement made by me in the Catalogue, that so far as the number and variety of its specimens are concerned, the series of aerolites in Calcutta stands among the first in the world.

Of the *Palæontologia Indica*, the first half of the detailed figures and descriptions of the Cretaceous Gastropoda of South India, has been published. This contained four parts, issued in anticipation of the regular dates for the quarterly publication, and as for the year from April 1867 to April 1868. This portion contains descriptions of 83 species, under 46 genera, with full analyses of the several families, sub-families, &c., and of their natural history relations, so as to form a standard guide for the student of this very important group of fossils. I have in all cases desired to bear in mind in our publications, the very different circumstances under which Indian readers are placed, as compared with similar students in Europe, from the absence of collections for comparison, and books for reference, and it has, therefore, been a steadily pursued object to render all our descriptions, catalogues, &c., as complete in themselves, and as detailed in their references, as possible. The preparation of the parts for the

coming year is far advanced, and they will be ready for issue punctually at the proper times. The issue for this year (4 parts) will I hope complete the *Cretaceous Gastropoda.*

It was not a little gratifying to find the high appreciation in which the publications of the Geological Survey were held by the geologists of Europe, during our visit last year. From many we had applications for these works, both the Memoirs and Palæontologia, which could not be acceded to, owing to the limited number of copies now available. I am glad also to be able to bear hearty testimony to the friendliness with which any proposals for exchange were invariably received, and I only regret that this excellent system of co-operation cannot be carried out to a much larger extent than at present.

During the year, a report on the coal seams found near Chanda on the Wurdah river, to the extreme south of the Nagpur territory, was submitted. As stated in last year's report, and alluded to above, Mr. W. T. Blanford had been deputed to carry on the lines of boundary of the several rock groups from their known limits to the north past Nagpur to the south, so as to trace out, if possible, the actual connection as he went along. This has been done as far south as about 19° 25′ of north latitude, or about the southern limits of the country included in Sheet 73 of the Indian Atlas. It is not intended to convey the idea, that such an extent of area has been worked out in detail, but the general features have been sketched in.

The rocks belonging to the coal-bearing series of India do not cover any very extensive area in the vicinity of Chanda. They extend from under the great flows of the Deccan traps, a little to the south of Wurrooda and Legaon, in an irregular band of an average width of about 20 miles to the Wurdah river where this band has diminished to about 12 miles in width. The further extension to the south of these rocks has yet to be traced out. It is difficult to arrive at any very satisfactory conclusions regarding the true distribution of these rocks, inasmuch as the area under which they extend, is so thickly and widely covered with recent and alluvial deposits, as almost entirely to conceal the solid rocks beneath. It is, however, probable that a very large portion of these rocks belong to the group developed in the immediate vicinity of Nagpur, and in which no coal seams have been found.

The coal yet discovered near Chanda is confined to two or three localities. One is about 10 miles due west of the station at a village called Kumbari. The bed is seen on both sides of the Wurdah, which here forms the boundary between the Woon district of Berar, and the Central Provinces. It is not easy, as no sufficient exposure of the coal has yet been made, to determine the exact thickness, but it seems to be between five and six feet; the upper part being much decomposed. It dips about 7° to the west-south-west. On the other side of the Wurdah the coal cut into varied from 2 feet to 15 inches in thickness, and as in the distance of less than 250 yards, it had thus diminished from five feet or rather more to less than half that thickness, the probability seems to be that the seam is very irregular if really constant at all, and that the quantity available is therefore not sufficiently steady to justify mining on any large scale. The quality of the coal is also poor. It yielded only 49 per cent. of fixed carbon, that is, not one-half of the weight. There is also present a considerable quantity of iron pyrites.

Mr. Blanford suggested that the extent of this bed should be proved by sinkings or borings near the village of Belora on the west, and a little to the west of the village of Googoori on the east side of the river.

A second locality is about 10 miles south of Chanda, and about 1½ miles north of Balarpur. It is seen on the right or Hydrabad bank of the Wurdah near the village of Sasti, and in the bed of the river is covered by the water excepting at the driest seasons. In the bank it was cut into for seven feet, of which six were coal, the top of the seam having been denuded, so that the total actual thickness could not be seen. It is all covered by alluvial clay forming the bank of the river. The upper three feet appeared to consist of fair coal, shaly here and there; the lower three feet of better quality, one foot at the bottom being the best. The rocks all round there are so concealed as to render it difficult to form any trustworthy opinion as to the extent or constancy of the seam. This knowledge can only be obtained by a careful series of borings or sinkings.

The sum of Rs. 152-11-3 has been paid into the public treasury, realized during the period referred to in this report by the sale of Memoirs, &c.

Library.—By the liberality of the Government of India, I was enabled this year to devote a portion of the large amount sanctioned as for the estimated expenses of the Survey, but undrawn in consequence of the absence of so many of our staff to procuring such standard series of works as were not within our reach from the very limited monthly sum allowed for

books, as well as standard series of specimens of fosils, &c., for the Museum. By this means, independently of the usual additions to our most valuable series, we have added more than one thousand volumes, including some rare and important series.

We continue to receive regularly from the societies and institutions with which we are in relationship of exchanges, their valuable transactions, journals, &c. These constitute a very large part of the regular additions to our library. And it is very greatly to be wished that this system of exchange might be extended largely. It would be by much the most effective method of making our own researches known to the scientific world, while the publications we should receive in return would more than counterbalance the cost. The literature of Geology, Mineralogy, Palæontology is rapidly increasing, and we find it impracticable even to keep up the supply of current publications on these subjects, from the small monthly grant appropriated to the purpose.

To our library (independently of the additions noticed above) have been added during the nine months under report (April to December) 630 volumes or parts, of which number 248 were presented.

MUSEUM.—The usual large and varied contributions to our Museum from the labours of the Geological Survey have continued during the season. None of the Survey parties have been working in any richly fossiliferous district, so that the number of fossils obtained in this way has not equalled that of some former years. From Europe we have procured a very extensive and grand series of fossils, both in originals and casts. When visiting European collections last year, I represented to the Right Hon'ble the Secretary of State the great draw-back to progress in India, which resulted from the absence of good standard collections for comparison, and ventured to recommend the purchase of a valuable collection then available, the result of some five-and-twenty years' researches by Prof. von Klipstein. This recommend-ation was sanctioned, and the collection was purchased. It has not yet been all delivered in this country, only a few out of more than two hundred cases having as yet arrived. And I will, therefore, defer entering into detail, until after it has been practicable to go over this series, and open it out, at least partially (for our present premises will not afford means of exhibiting it, even to the most limited extent).

During our brief tour in Europe we also received some valuable donations of fossils, minerals and rocks, all of which have still to arrive. A detailed list of these will be pre-pared as they are opened out. *Calcutta, 31st March* 1868.

BLANFORD, W. T., on the Coal Seams of the Tawa valley, Baitool District, Central Provinces.—The coals of the Tawa Valley have frequently been reported upon, the last and most complete account of them being that given by Mr. J. G. Medlicott, of the Geological Survey. Full details of the different seams are given in the body of his report "on the Geological structure of the Central Portion of the Nerbudda District" (Memoirs of the Geological Survey of India, Vol. II.) or in the Appendix, page 268.

The principal localities described were the following—

1. Rawundeo, on the Tawa River: 21 feet 2 inches of coal seen in 8 distinct outcrops, besides some repetitions. Two of the seams are 4 feet at least in thickness at their outcrops.

2. Murdunpur and Kotri on the Machna, a tributary of the Tawa: two seams; one 3 feet thick, the other 6 inches only.

3. Sonadi, on the Bora Nuddi, another tributary: two seams, 19 and 10 inches thick respectively.

4. Sooki Nuddi, a 3rd tributary: two thin seams, 3 and 2½ inches thick respectively, and of course worthless.

Besides these, there are two seams, one 2 feet 3 inches thick, and a lower seam of 3 inches occurring on the Machna River between Shapoor and Murdanpoor mentioned in the detailed Section at page 160, but not referred to in the Appendix, being probably considered by Mr. Medlicott merely a repetition of the Murdanpoor outcrops.

No new localities have since been discovered, so far as I can learn. I received information from a native of the occurrence of *kala patthar*, near Kesla, which would be an important locality, being within 12 miles of the railway, while the nearest known outcrop of coal is double that distance, but on visiting the spot, I found the "black stone" indicated to be a sandstone.

But although no new localities have been met with, the progress in our knowledge of the coal-bearing rocks of India during the 10 years which have elapsed since Mr. Medlicott examined the Tawa Valley has been so great that it appeared possible that some additional particulars might be noted, and that a better idea of the mining prospects of the locality could be formed. In this anticipation I have not been wholly disappointed, although I regret to say that the result of my examination is to induce me to take an even more unfavorable view of the coal seams of the Tawa Valley than Mr. Medlicott did. I doubt if a single seam is known to occur in the valley which could be mined to any depth with profit under existing circumstances, and with one possible, but very dubious exception, I am decidedly of opinion that no seam could be worked under any possible circumstances. The possible exception is in the Rawundeo section, to which Mr. Medlicott particularly called attention, but there are some peculiarities, connected with the seams there found, which make me think their availability for mining purposes doubtful.

In order to show my reasons for the unfavorable opinion formed, I shall proceed briefly to describe the several localities. It must be remembered that these are all outcrops exposed in streams, and that the sand in the bed of the stream shifts from season to season exposing portions of rock and outcrops at one time, which it conceals at others. This is especially the case with those coal seams which usually underlie beds of coarse sandstone, and the latter, being hard, stand up in small terrace-shaped masses against which the sand accumulates, concealing the softer coal beds beneath. For this reason it is improbable that any two successive observers will see exactly the same section, if their visit be in different years, and in some cases I was unable to find again seams mentioned by Mr. Medlicott, and, *vice versâ*, I saw some which he, I believe, did not.

1. Sonadi.—I saw coal in three places here. Mr. Medlicott only in two. The highest seam is about 19 inches thick, with 4 or 5 inches of shale overlying it, and, upon this, coarse sandstone. All other seams are thinner. The second seam in descending order is 10 inches thick, with a roof of coarse sandstone. Beneath this comes—

	feet.	inches.
Coarse sandstone, about	10	0
Coal	0	6
Shale and shaly sandstone	4	0
Coal	0	8

About 100 yards further south another seam occurs, about 1 foot 6 inches thick of coal and shale mixed. The roof here also is of coarse sandstone.

2. Sooki Nulla.—Only strings 3 or 4 inches thick occur, as noted by Mr. Medlicott.

3. About 2 miles east of Shapur, in the Machna River, a seam 2 feet 3 inches thick is seen associated with shale, and a lower seam, 3 inches thick, as above mentioned. The upper seam can be traced for a short distance, about 100 yards.

4. Murdanpur, on the Machna.—Mr. Medlicott saw two seams here ; one was probably concealed by sand at the time of my visit, but it was only 6 inches thick. The other amounts to 3 feet in places, but is extremely variable. The roof is again coarse sandstone. The seam is seen for several yards along the south (right) bank of the stream, but is not seen, where, if continuous, it should recur on the north bank. It is possible that there may be a fault, but I could find no indication of one ; it appeared to me that the associated sandstone re-appeared without the coal seam, and my impression was that the latter had thinned out and vanished completely.

5. Rawundeo, on the Tawa River.—A careful description and a measured section of this locality are given by Mr Medlicott at page 154 of the Memoirs. Yet such changes have been produced by the stream in 10 years that I had much difficulty in recognizing several of the beds. I believe the rocks in the upper part of the section to be better exposed on the whole now than they were in 1855, while the lower portion is now comparatively concealed. I counted 11 outcrops of coal, Mr. Medlicott 13, of which he considers several to be repetitions caused by small faults. At the same time he mentions that there was no clear evidence of faulting, and I certainly do not think there is any in the upper part of the section, and I think, so far as the number of seams exposed is concerned, that he has underrated the resources of the spot rather than otherwise. Some of the coal is of excellent quality, and one or two seams are 4 feet thick, in places at all events

On the other hand the roof is frequently, though not always, coarse sandstone. The seams are not of even thickness throughout, some, perhaps all, being very variable. Most of them are only seen for a few feet, and in only two cases could I trace them the whole distance across the river. One so traced varied but slightly in thickness, being about 1 foot to 1 foot 3 inches; the other was 2 feet thick on one bank of the stream, and gradually thinned away, vanishing completely before reaching the other bank, less than 50 yards distant. Both these seams were associated with flags and shales.

It will thus be seen that, except at Rawundeo, not one seam is known to occur exceeding 3 feet in thickness, and I doubt if any seam of that thickness can be profitably mined in India. I am aware that much thinner seams are worked in England, some, I believe, not exceeding 18 inches, though that is exceptional. But in England there are three advantages at least which are wanting in India. These are—1. A large local demand; 2. Excellence of quality; 3. A skilled mining population.

In India, in a place like the Tawa Valley, there is no local demand, nor is it very probable that there ever will be. The best Indian coal from the Damuda beds is about half as good as the best English coal, that is, if used in a steam engine, for instance, it takes twice as much Indian coal to do the same work. The value consequently, weight for weight, is about one-half, and a 3 feet seam of Damuda coal is, on this account alone, only an equivalent of an 18 inch seam of English coal. Another disadvantage entailed by the inferiority of quality, is of course, increased expense for carriage.

The want of skilled labour causes more coal to be cut to waste besides largely increasing the cost of superintendence.

Taking all the disadvantages into consideration, my own impression is that from 4 feet 6 inches to 5 feet is the minimum thickness of a coal seam which can be profitably mined in India under ordinary circumstances. In the immediate neighbourhood of a railway, or of any other large source of demand, perhaps rather thinner seams might be worked.

Of course a considerable quantity of coal, some thousands of tons in many cases, may be profitably extracted from thinner seams near the surface.

Of course too, the conditions of the profitable mining of Indian coal depend upon a variety of circumstances liable to change. A mining population might gradually spring up, the demand for fuel may, and probably will, increase, while other supplies may fail or increase in value to such an exent as to raise the price of the article permanently. These other supplies, at present, are wood and English coal, either of which may at any time become unprocurable. On the other hand, if India ever attains a civilization at all approaching that of Europe, it will undoubtedly grow timber for fuel largely, as is done in all other civilized countries not rich in coal. At present the principal efforts of the whole Native population of India, and of no inconsiderable proportion of the European population, appear to be devoted to the destruction of the forests, and it is but fair to say that their labours have been rewarded with great success.

Supposing, however, that seams of 4 feet in thickness could be worked or that two or three seams were mined from one shaft, thus diminishing the cost of sinking and of machinery, there appears a possibility that the Rawundeo coal might be mined, especially as the quality is, in some seams, exceptionally good. But there is still one point which must be satisfactorily determined before the seams could be pronounced workable, and that is the question how far the seams can be trusted to be constant in thickness.

Where merely small sections are seen in the banks of rivers, not extending frequently more than 5 or 6 yards, this question is difficult to answer. Of all the seams seen in the Tawa Machna, and Bora streams, the outcrops of not more than 3 or 4 can be traced for 50 yards, and out of these few, one in the Tawa dwindles from 2 feet to nothing in that distance, and a second at Murdunpoor on the Machna, appears to do the same, and certainly, out of a total of barely 3 feet, varies as much as a foot within 20 yards. Moreover, nothing is more common than to find coal seams of variable thickness when their roof consists of coarse sandstone, it appears always to mark slight local unconformity, and denudation of the coal seam beneath. But in the case of the seam at Rawundeo which is seen to thin out, its irregularity is not due to this cause, the roof being of flaggy sandstone.

In describing the Ranigunj coal field, I showed that there were two sub-divisions of the coal bearing rocks or Damudas, the lower containing numerous coal seams of great size

but so variable in quality and thickness, that it was doubtful if any could be largely mined, The beds were characterized by frequent alternations of shales, flaggy beds and massive sandstones. In the higher sub-division of the Ranigunj beds the alternations were less numerous, the several beds much thicker, and the coal seams more constant. I am inclined to believe that the beds of the Tawa Valley resemble those of the lower or Barakar series of the Ranigunj field in the peculiarities of the coal seams, as they certainly do in their position at the base of the coal measures.*

A very important and interesting question is the probability of the occurrence of coal in the more northern portion of the Tawa Valley near Kesla and Bagra; in the first place, because coal occurring there might belong to the higher and richer beds; and, secondly, because it would be so much nearer to the line of railway. Time did not allow me to examine the valley thoroughly, but a cursory inspection of the neighbourhood of Bordha and Kesla induced me to believe that the rocks there occurring are very possibly higher in position than the true coal bearing beds of the Damudas. *April 4th*, 1866.

H. B. MEDLICOTT, On the prospects of useful Coal being found in the GARROW HILLS, Bengal.—My report on the coal resources of the Garrow Hills admits of being very brief. I have only to indicate the very fallacious nature of the statements, upon which expectations have been founded.

The region to which my remarks will be limited, as bearing upon the question of the northern extension of the Eastern Bengal Railway, comprises the hills to the south and east of the Bramahpootra, bordering the Mymensing and Goalpara Districts. It forms the recently created jurisdiction of the Garrow Hills. It thus excludes the Cossiah Hills and Silhet, of which the coal has already been cursorily described, and which would be beyond the range of the object, indicated as the special reason for my mission. It will be seen that the spurious coal of the Garrow Hills is geologically distinct from most of that already so well-known as Silhet, or Cherra coal.

As it was conjectured, and in the main correctly, that the Garrow Hills were geologically, as well as geographically, the continuation of the Cossiah Hills, I formed the plan to begin at Cherrapoonji, and so to work westward from the known to the unknown. Owing to the lateness of the season at which the project was taken up, I started from Calcutta before final orders were received from the Home Office. But in consequence of the great delay subsequently in procuring elephants, the only practicable carriage in these districts, I was unable to leave Cherrapoonji until the 22nd of January. I was, therefore, prevented from carrying on the connection of the sections so closely or continuously as I had wished. I had to hurry on to the ground where the principal object of research lay. However this unavoidable haste may have diminished the scientific results of my season's work, it has not, I consider, affected the judgment I have to give on the practical question proposed. The circumstances of the case are so simple as to admit of a very definite opinion.

I have examined every coal outcrop in the Garrow Hills of which I could obtain any information. They are grouped in two localities; one on the Sumesurri river, north of Shushung-Durgapur in Mymensing, the other in the neighbourhood of Harigaon, at the west base of the hills near the Bramahpootra. It is the latter that has chiefly attracted attention, as being so favorably situated with reference to the great river and to Assam. The former position is more than fifty miles from the Bramahpootra, besides being separated from the plains by a zone or belt of hills, ten miles wide, and being on an unnavigable stream. Both localities are marked on the Revenue Survey maps of Mymensing and Goalpara as coal-bearing; and, as far as I am aware, the coal was first brought to notice by the surveyors. There can be little doubt, that the same coal is more or less continuous between these two localities, and that numerous other outcrops could easily be found by any one having a slight knowledge of the rocks; but, apart from a consideration of the absence of any prospect of improvement in the character of the coal, the difficulties of position with reference to the means of transport, would rapidly amount to prohibition, even in the case of a very good coal, in proceeding eastwards from Harigaon. After seeing the section on the Sumesurri, and finding that I should have little to occupy me in the outermost hills, I wished much to be able to proceed up the Nitai, and so along the band of coal-bearing

* It is possible that the Mopani beds, which, however, I have not seen, belong to the upper or Ranigunj series, as do, I think, some and perhaps all of the Pench beds also.

strata to Harigaon; but I could not have attempted this without long preconcerted arrangements with Lieutenant Williamson, having had repeated official warnings not to venture into the Garrow country unsupported.

The configuration of the Garrow Hills differs considerably from that of the Cossiah Hills; while the corresponding features in each are determined by the same geological structure. The high table-land range of the Cossiah Hills rises almost abruptly from the plains of Silhet, and is formed by undisturbed strata belonging to the cretaceous and nummulitic formations, resting upon a basis of crystalline (metamorphic and granitic) rocks. There is under the Cossiah Hills only a very narrow band of much lower fringing ridges, formed of those same, or of younger, stratified rocks, but greatly broken from their original horizontality. The outermost of these are very low, being composed of the comparatively soft rocks of age later than the nummulitic; while the ridges of intermediate position and elevation are for the most part determined by the nummulitic limestone, or by the cretaceous sandstone. The higher ridges of the Garrow Hills, on the contrary, are scarcely visible from the plains of Mymensing in ordinary weather. Passing westwards from Cherrapoonji, the zone of disturbed rocks and lower ridges intervening between the table-land and the plains becomes wider, the boundary of the main hills having taken a W. N. W. course, while the outer limit of the minor hills maintains its E. W. direction. It is found throughout that the great change in the form and elevation of the hills is consistent with the appearance of the crystalline rocks: on the Sumesurri, the gneiss comes in close to the north of Seju; and Tura mountain (upon which Lieutenant Williamson has just established his head quarters) is the western termination of the great plateau of Shillong and Cherra, and is formed of gneiss with the cretaceous sandstone resting on its S. W base. In the same continuation, up to the edge of the Bramahpootra at Singmari, the crystalline rocks appear almost continuously, under a thin covering of the same sandstone. No formation seems to be introduced in the western expansion of the lower hills, that is, not more or less represented in the shorter but steeper sections to eastwards. Just about Laour, in Silhet, the lowest ridges of the outer hills are altogether cut away for a considerable length; and the nummulitic limestone rises abruptly from the alluvium. The supra-nummulitic strata, however, soon re-appear to the west, in force: on the Sumesurri they are ten miles across; and further west, on a line S. W. from Tura, they are probably much wider.

There is a contrast in the features as well as in the extent of these minor hills in the Garrow and Cossiah regions. To the east they present much difference of elevation, and variety of outline; whereas from the summit of Tura one overlooks, from its base to the plains, a monotonous expanse of insignificant hills. This seems due to several circumstances, influencing the results of denudation; there is a gradual diminution westwards of disturbance in the strata, accompanied by a less induration of the older rocks; and especially is the difference of features due to the almost total extinction westwards of the limestone, a rock always remarkable for its picturesque forms of weathering.

I have said that the coal of the Garrow Hills has been examined in two widely separate localities. Although, on the Sumesurri, its position alone would preclude the profitable extraction even of an otherwise valuable coal, it will be well to describe this locality, as the section is much more distinct than that of the more westerly region, and the boundaries of the several groups of rocks can be easily fixed approximately. The Rajah of Shushung, who lays claim to the sovereignty of a large tract of hills, although to all appearance his authority is unrecognised by the resident Garrows, has had search made for coal along the banks of the Sumesurri. In this way two outcrops have been opened out; and a little coal extracted for trial. Both outcrops belong, I believe, to the same seam, repeated at the surface by contortions of the strata. It occurs near the base of the whole stratified series, within a few yards of the underlying crystalline rocks.

The section on the Sumesurri is as follows:—At the outermost skirts of hills, below Bijessur, we find the sands and subordinate clays of the group next above the nummulitic. Here they dip at 40° or 50° to southward, being very much more disturbed than at any point higher up the river. They rapidly settle down to a very small slope and even to horizontality; so much so that through the long windings of the river above and below Salagaou, the very same beds are traceable near the water line. The most distinctive rock of this group is a fine, soft, greenish-yellow or gray sandstone, generally massive and falsebedded, but also in very regularly laminated layers. On the line of the Lekong nuddi, these soft rocks rise

again to the north at about 5°; and a little above the confluence, after some few score yards of blank section, rocks of an older type crop out with dips of 40° and 50° to southwards*.

Ryuk Lamapara is on a ridge of fine, yellowish, white sandstone of the type associated with the nummulitic strata. The dip is here 20° to S. S. W; but it immediately becomes lower, and all through the valley of Ryuk Ujanpara the nummulitic limestone shows on the river bank, quite horizontal. This rock is already greatly changed from its conditions in Silhet; instead of several thick bands of strong pure limestone, there is now altogether about 30 or 40 feet, and for the most part earthy, ochreous and concretionary; selected portions of it might make good hydraulic lime and cement. It seems to be overlaid by earthy shaley beds, that are rarely exposed; but I could not trace any symptoms of a carbonaceous deposit in this position, which is that of the coal at Cherra.

The limestone runs quite horizontally up to the very base of a steep ridge running W. N. W.; but within ten feet it bends up to a high dip, and is seen resting directly on a strong, coarsish, pale sandstone more or less felspathic. The two are thus apparently conformable; and there would be no direct reason for considering them of very distinct ages. This ridge is very narrow; and there is a good section of it in the river. There may be about 200 feet of the sandstone with occasional partings of carbonaceous shale. Along the northern flank there is a thick band of such shale, in the midst of which occurs the coal seam. It is here a good deal crushed, being close to an axis of flexure, and dips at 80° to S. S. W. It is altogether about three feet thick, but very unequally carbonaceous, being locally split by strings of clay and of sand; and it contains but few thin strings of coaly substance. The mass of what would be extracted as coal is a highly resinous batt or shale, full of small nests and strings of a kind of amber; it gives a woody sound when struck, is very tough, and breaks with a large conchoidal fracture; the lamination is observable throughout; but the whole lights readily and burns freely, leaving a skeleton of ash.

There is a blank section of about 100 yards on the north side of the ridge, and then strong sandstone, like that over the coal, appears on both banks, with a very slight northerly inclination, continuing so throughout the long N. S. reach of the river. Where the river turns eastward this dip increases, bringing down a limestone identical with that of Ryuk, and resting on the strong sandstone. There is here a shallow synclinal, the limestone being q. p. horizontal opposite Seju Lamapara, and rising rapidly on the south flank of the ridge at the point of which stands Seju Ujanpara. The streamlets down the face of this ridge undercut the strata, and disclose the coal seam at about the same depth from the limestone as before. These rocks all strike into the gorge of the Sumesurri at and north of Seju Ujanpara; the coal and the soft shales associated with it are of course eroded and concealed, but we now find the beds which underlie them—these are about 100 feet of strong coarse sandstones just like those over the coal; and they rest against and upon the gneiss. There is an excellent section of the junction: the dip of the sandstone increases rapidly, being 80° to S. W. at the contact; but it is a natural junction, parallel to the dip of the sandstone, the base of which contains rolled pebbles and boulders of the crystallines. The chief mass of the high irregular ridge over Seju is of gneiss, great blocks of this rock abounding in the steep watercourses through the sandstones at the base of the ridge.

The coal near Seju is precisely similar to that already described, only perhaps a little better; and the sequences of the strata in the two places so exactly correspond, that there can be little doubt the coal belongs to one and the same band; the southern outcrop being due to the remarkable flexure of the rocks between the valleys of Ryuk and Seju. Whatever little use might be made of this coal, if required on the spot, it is evident that it would not supply any extensive demand, or repay any difficult transport. The latter obstacle seems insuperable: the Sumesurri, although a considerable stream, is choked with silt throughout the greater part of its course below Ryuk, where the rapids begin to be troublesome.

If the great thickness of cretaceous rocks, known in the section of the Cossiah hills, is represented at all on the Sumesurri, it must be by these bottom sandstones and shales containing the coal, here 400 to 500 feet in thickness. All the circumstances support the conjecture that such is the case; as, the description of the rocks and their mode of relation to the nummulitic limestone. In the Cossiah hills too there are frequent symptoms of a carbonaceous element in the cretaceous rocks. Shortly before leaving Cherrapoonji I noticed a bed of shale,

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* The limestone noted on the district map of Mymensing—(scale, 4 miles equal one inch) just above Salagaon Ujanpara, does not show on the river; it is probably a mistake.

full of obscure plant remains, associated with the conglomerates at the very base of the section under Mamluh on the west; and it is more than probable that some of the local coal beds of the Cherra region, as, for instance, that at Moubelarka (from which the supply for Shillong is now taken), belong to the cretaceous and not to the nummulitic deposits.

I wished much to go up the Koylas mountain from Seju; but the attempt would have been useless, without some more influential protector than the pretended sovereign, the Rajah of Shushung, through whose assistance I got along the river as far as Seju. The slight sketch given of this tract of the hills on the maps is very misleading, as to the relative importance of the several hills: Koylas, though marked rather more faintly, is about three times as high as any of the hills to west and south of it. One can see at a distance, by the sub-horizontal tiers of cliffs on the S. W. face, that at least the upper half of the mountain is of stratified rocks. It would seem too on the map to stand outside the run of the gneiss boundary at Seju, and to be on the stripe of the band of sub-horizontal rocks just south of Seju; thus suggesting that the whole mass of the hill is of these unaltered sedimentary rocks. If, however, such is the case,—that the cretaceous beds pass under Koylas at the same elevation as in the Sumesurri—the top of the hill must be formed of the younger tertiary rocks, at a much greater elevation than these have as yet been observed west of Jynteah. I rather conjecture that there is a sharp bend in the boundary of the crystalline rocks, and that these form the base of Koylas; in which case the cliffs noticed on the summit may be altogether composed of cretaceous and nummulitic rocks. It is possible, indeed, that the peak of Koylas may be formed of a remnant of the submetamorphic sandstones of Shillong.

As has been already stated, it is in the hills bordering the Bramahpootra, that the question of a coal supply is most important, and where the greatest hopes have been raised by the published statements of discovery. These statements are, as far as I am aware, based upon the investigations of Mr. James Bedford who made a survey of this district in 1842. The published maps of Mr. Bedford's coal discoveries are very imperfect reductions from the original manuscript, of which a tracing was most obligingly supplied to me from the Surveyor General's Office. In these maps the facts given are of two kinds: there are several outcrops of coal noticed in the hills north of Harigaon; and coal is said to exist in the hills south of Harigaon upon the evidence of debris found in the streams. I will first notice the former.

A glance at the geological sketch map will show that Mr. Bedford's coal outcrops at Salkura, Champagiri and Mirampara are on the exact run of the Seju bed; and that the circumstances of the sections are very similar. Those three localities are on the low table-land range of Singmari, which is now much eroded into irregular transverse ridges. All over this range the crystalline rocks weather out from beneath a thin capping of coarse friable sandstone, often conglomeritic; and at the three places mentioned, a local deposit of shale or of clay occurs between the sandstone and the gneiss, and which earthy deposit is very partially impregnated with carbonaceous matter. At Salkura and Mirampara the stuff is mainly a resinous shale, a very poor representative of the Seju coal, but quite of the same character; at Champagiri, more to the north and between the other two places, it is a thick bed of dark stiff clay, with insignificant strings of lignite through it. At Salkura the gneiss shows continuously in the stream at about ten feet under the shale. At Champagiri and Mirampara, besides occurring for some distance in the bed of the streams between banks of the sandstone, the gneiss is seen at the edge of the range at a higher level than the shales, with pebbly sandstone resting on it; the shales having altogether died out. All the streams form rapids or falls over the crystalline rocks at the edge of the range. It seems strange that Mr. Bedford, when he attempts to give definite names to the varieties of the overlying rocks, and although he notices these water-falls, should have failed to make mention of the crystalline rocks, the occurrence of which so gravely affects the prospects of the reported coal-field.

It must have been a very small and carefully selected fragment from these "coal-beds" that yielded the analysis published by the Coal Committee; and it is not to be wondered at, that Mr. Sweetland failed to fulfil his engagement to "put the Committee in possession of more satisfactory samples than they had yet seen." It would require months of labor to obtain a maund of anything that would support combustion. These beds have no relation to "the brown coal formation;" but they were most correctly condemned by the Committee as "belonging to one or more small isolated basins of a spurious coal formation, and are not

likely to lead to any important result." Unfortunately, in the very next paragraph of their report, the Committee pass an encouraging judgment upon much more precarious evidence.

Passing to E. S. E. we find the same conditions to obtain as in the Singmari ridge. The main mass of Harigaon hill is of gneiss with the thick sandstones resting against and upon its southern base either horizontal or with a very slight inclination to the south, and again at Tura, the summit of which is about eight miles to E. 30° S. of Harigaon hill, the station at the south-west base is just to north of the gneiss boundary; and in the stream which drains this flank of the mountain (it is the head waters of the Bunarossi) the gneiss appears in the bed for nearly a mile below the general longitudinal boundary, between spurs formed of the overlying horizontal sandstone. Down this stream I was taken to see a coal bed; it consists of a few sticks of lignite scattered through the sandstone, at six to ten feet above the floor of gneiss.

At Domulgiri, the stage between Harigaon and Tura, I was fortunate enough to hit upon the nummulitic limestone; but for the clearing made for the few temporary buildings, it would probably have escaped notice. The blocks of rusty stone heaped out of the way are evidently derived from a bed in place—the remains of a very thin band, probably a single bed, of ochreous earthy concretionary limestone full of nummulites. The shaly clays that overlie it are exposed on the side cuttings of the road leading up the hill towards Tura; and the cretaceous sandstone occurs in the river immediately below. In kind and in position, everything corresponds with what has been described in the section of the Sumesurri; but the limestone is reduced to this miserable remnant, useless for any practical purpose. This is the completion of the tendency that was already so well marked in the limestone band on the Sumesurri, as compared with the same rock in the Silhet sections.

As far as I penetrated to the south of Harigaon I could not discover even the debris of the rocks overlying the nummulitics; so I am unable even approximately to assign the position of that line of boundary. It must be followed up continuously from the more easterly sections.

The very small inclination, but little removed from horizontality, of the strata in this region would render the tracing of the boundaries between the formations, as carved out by the tortuous valleys through these low hills, a very intricate business indeed.

But there is another geological circumstance that adds much to this difficulty of fixing the boundaries, and greatly aggravates the obstruction to observation offered by the dense character of the vegetation. This is the occurrence of an older diluvial formation. At the point of the spur over Domulgiri, on the spot where Lieutenant Williamson has built his hut, this deposit is betrayed by the rolled blocks of crystalline rocks. But it is often a sand, which, as partially indurated, cannot be certainly distinguished in the small obscure sections, such as almost solely are exposed to view, from the rocks of the underlying formations. Along the outer margin of the hills in the Karibari region, this obstruction amounts to a prohibition of anything like close work. In exploring the hills from Mohindrogunj and Kakreepara, I could never think, with any certainty, upon what ground I was standing. There can be little doubt that this deep deposit in which the low hills are half smothered corresponds with that of the well-known tract in Mymensing and Dacca called the Madhopur jungle. The semi-laterite clay, which is there the chief rock, occurs too among these hills.

We can now discuss the second statement regarding the coal resources of these hills. The Coal Committee remarks, after condemning the only observed outcrops—"This brown-coal formation is not to be confounded with the indications of bituminous coal in the same district, afforded by drifted specimens in the bed of the Bunarossi river." On Mr. Bedford's map, the Kalu above Domulgiri and the Bunarossi above Dumnigaon are represented as trending indefinitely to the south, and are labelled "coal exists in these hills." There are several errors in this information, amounting to a complete misrepresentation of fact. From Domulgiri the Kalu keeps altogether to the north, passing only through the cretaceous band to the gneiss, and drains the northern flank of Tura. From Dumnigaon, the Bunarossi bends steadily round to the north, and drains the western and southern flanks of Tura. I examined the bed of this river for several miles above Dumnigaon: fragments of anything that could be called coal are exceedingly rare in it; and are in quality, as well as in quantity, just what might be expected to be derived from the sticks of lignite I had noticed in the cretaceous sandstone near the source of the river, and

such as might be procured at Champagiri or Mirampara—fragments of pure jetty lignite. I have no doubt that such were what the Committee inaccurately speak of as 'bituminous coal'.

Thus it is plain to me that the unknown, undescribed, and unauthenticated "bituminous coal" came from the condemned "brown-coal formation;" and that no evidence whatever exists of any other carbonaceous deposit in the Garrow Hills.

Having satisfied myself upon the merits of all the evidence before me, and considering that evidence sufficient to form a judgment upon, I did not feel called upon to incur any further loss of time upon the object by hunting for a 'find' without the smallest prospect of success. But should any adventurous man, unsatisfied with the preceding explanations, wish to explore further, I would offer some remarks for his assistance.

The nummulitic formation seems to exist here, on the whole, in as great force as in Silhet, but the valuable coal there associated with it has not been detected here. The case is slightly different from that of the limestone: this rock could scarcely escape observation if it existed; but coal outcrops are habitually eroded and concealed. I cannot but think, however, that some hint of its presence would have been brought to light, even by such search as has been made. The best known (if not all) the nummulitic coal in the Cossiah Hills occurs above limestone.

Of the cretaceous coal it may be said, that the described outcrops are all at the very margin of the original area of deposition, and that the same tendency to form coal may have been much more developed further out in the formation. There would be no asserting the contrary; but also, no *a priori* confirmation can be given to such a conjecture. It is, however, evident, that the horizon of the carbonaceous band in this formation very soon passes beneath the drainage level of the country, and it is only by boring that this supposition of development can be fairly tested; and only by regular pit-mining with a prodigious water discharge, that a coal in that position could be extracted.

It would seem at first sight that the cretaceous beds on the Singmari range had overlapped their general line of boundary, and might extend to any distance northwards, with expansion of the coaly band. The feature is indeed a remarkable one; showing that, to some extent, this terminal configuration of the crystalline axis is of pre-cretaceous origin; but it does not extend far;—at the most northerly points of this range, at Dhepkai and Singmari, the metamorphic rocks are in place, and they occur at all points to the north where rock has been observed in the valley; as at Dhubri, Bengal Khatar, and all along the southern road to Goalpara. 28*th March*, 1868.

MALLET, F. R.—COPPER IN BUNDLECUND.—In the 2nd Volume of the Memoirs of the Geological Survey of India, p. 35, notice is taken of the asserted presence of copper near the village of Sorai or Sounrai, west of the Dessaun river, in the Shahgurh district. Mr. Medlicott there states that "when at Nagode, Major Ellis had drawn my attention to this place, Sorai, as having once yielded large supplies of copper." The Rajah of Shahgurh had mentioned it with a view to have the place examined. The specimens he gave were all rounded as if rolled by water, and "with a polish as if for many a long day they had lain in a greasy pocket." None gave any evidence of having been broken from a vein. Mr. Medlicott visited the place, but could get no information. After persisting for sometime he was shown a place just on the south of the village where, it was said, copper had been extracted. It was a shallow trench through the limestone. Mr. Medlicott could not find a trace of anything like a metalliferous mineral. During the past season I heard of this place while working to the north of it, and in consequence I proceeded to the place. It is on the Bijawur rocks, at the edge of the crystallines.

A prisoner had told the Assistant Commissioner that he could show the place where copper existed, and on being taken to the spot had pointed this out. The hole sunk by the Assistant Commissioner was in a fissure formed on a joint in the Bijawur limestone, heading N. E.—S. W., the walls of which were 12 to 15 inches apart. This fissure had been filled up with clay and pebbles of various kinds, Bijawur limestone, hornstone, Bijawur ferruginous beds, Vindhyan sandstones, &c., but none of the crystalline rocks. At two feet from the top were bits of brick and charcoal, and at six feet from the surface, there was a quantity of copper ore in rolled lumps, obviously the debris of some vein,

mixed up with the pebbles of other rocks. It is possible that the lower part of the rubbish is much older than the upper, but there is no clearly marked line between them. There is, however, no copper near the top, and no bricks, &c., near the bottom. If the rubbish be of one age, the bricks would show that the fissure had been filled in within a comparatively recent period, and it seemed not impossible that the ore was the result of former workings washed into the fissure by surface water. I then tried to find any lode; the pebbles associated with the copper are so various as to give no clue to its locality if it exist, excepting the probability of its being in the Bijawur and not in the crystalline rocks. I carefully examined the neighbourhood for any indications of copper without finding a trace. I also searched the bed of the stream which drains the locality for any loose pebbles, but without any result. The only way to prove it really, therefore, seemed to me to sink trial pits. I discussed the matter with the Assistant Commissioner and gave him what information I could on the subject; he expressed his determination to carry on the investigation which he had commenced, and it is to be hoped that his researches will be successful. *April*, 1868.

METEORITES.—It is well known to those who have studied the structure and character of meteorites that, while no single element has been found in these bodies which does not occur on our globe, and while a very large number of the combinations of these elements to form mineral species which occur in meteorites occur also on the earth, there still remain a few minerals which are specially confined to these bodies. The most important of these are Native iron; Schreibersite (or the phosphide of iron and nickel); and Troilite, or what is generally supposed to be the protosulphide of iron. Every extension of accurate research which tends to diminish this number of minerals special to meteorites is of very high interest as bearing on the conclusions to be drawn from their composition regarding the origin and physical condition of the planetary bodies. And in this point of view, the recent researches of M. Stanislas Meunier, the able adjunct to Professor A. Daubrée, in charge of the mineralogical collection at the Jardin des Plantes, Paris, possess a very wide interest. At present we will only allude to his researches on the nature of Troilite, of which we give here a summary. M. Meunier has also recently published a very excellent treatise, Étude descriptive theorique et experimentale sur les METEORITES, 8vo., Paris, 1867.

On the nature of Troilite, S. MEUNIER. "It is known that certain meteorites, that of Orgueil, for example, contain small crystals of the second system formed of a sulphide of iron, having the composition and characters of magnetic pyrites, or Pyrrhotine. This sulphide, of which the formula is $Fe^7 S^8$, enters into the composition of many terrestrial rocks also.

Besides Pyrrhotine, meteorites very often present another mineral of very similar composition and which up to the present never has been found crystallized. To this the name of Troilite has been given. A certain number of Mineralogists, following Mr. Lawrence Smith, attribute to it the formula Fe S, and consequently regard it as constituting the protosulphide of iron. This distinction between Troilite and Pyrrhotine is probably not so marked as is generally supposed. As seen, the difference in composition is very slight, and the physical properties of the two appear very similar.

I have had lately opportunities of analysing many specimens of Troilite from the meteoric irons of Charcas and Toluca, and the numbers which I have obtained lead me to think that this mineral is more closely allied to magnetic pyrites, than to the protosulphide of iron. The results of these analyses will be published separately when they have been completed and extended to a larger number of specimens, but I wish at once to call attention to a reaction, which seems in all cases easily to distinguish the protosulphide of iron from magnetic pyrites, and, *a fortiori*, from compounds more highly sulphuretted.

It seems, at the first view, that this distinction would be very easy, but in reality it is not so. The two minerals are of the same bronze yellow colour, their specific gravities are very close (4·5 for Pyrrhotine, 4·7 for Troilite), and variable within certain limits in different specimens: the *mean* composition differs very little, Pyrrhotine contains (in the mean of results) 39·6 of sulphur to 60·4 of iron, and Troilite, in the mean, has 36·4 of sulphur to 63·6 of iron; both are feebly attracted by the magnet; both fuse freely in the reducing flame to a black globule, strongly magnetic; both finally dissolve easily in Hydrochloric acid, with a very abundant discharge of sulphuretted hydrogen.

It is known also that magnetic pyrites is distinguished from the protosulphide by the deposit of sulphur which it gives, when treated with acids, but this reaction, very marked when

we are dealing with masses very pure and very abundant, is not applicable to the sulphides of meteorites. Besides the fact that we can only operate upon very small quantities of Troilite, and can therefore in every case only obtain a very trifling deposit of sulphur, it must be remembered that this mineral is very far from dissolving entirely in acids. It gives a residue, in which we find carbon in the form of graphite, small hyaline grains which have a composition very close to that of quartz, and small crystals which can be referred to various silicates.

In the practical point of view, therefore, we must seek for some reaction characteristic for one at least of the two sulphides in question. With this object I have submitted the protosulphide of iron and Pyrrhotine to a very large number of comparative trials.

I shall not stop to show that the protosulphide precipitates metallic copper from its solution exactly as iron itself does, whilst the Pyrrhotine does not; the chemical reaction in virtue of which copper is so reduced offers some interesting peculiarities, and I have submitted these to a special study. (1) Without anticipating the details, I may say that the protosulphide of iron obtained by the wet way gives rise to a metallic precipitation, as well as the same compound obtained in the dry way; nevertheless the phenomenon is more easily perceived in the latter case, inasmuch as the extreme sub-division of the black sulphide leads the copper to deposit itself in grains not discernible by the eye.

I have been able to replace the chemically pure protosulphide of iron by a compound containing a little more sulphur, produced by the preparation of sulphuretted hydrogen, in fusing together iron and sulphur. But as soon as the proportion of the sulphur approached that demanded by the formula of Pyrrhotine, precipitation ceased to be possible.

With a sufficient quantity of protosulphide of iron, a copper solution can be deprived of all the copper it contains. This experiment can be easily made with a solution of the sulphate of the binoxide of copper; again, with a sufficient quantity of sulphate of copper, all the iron can be removed from the black precipitate which is obtained by the action of sulpho-hydrate of ammonia on an iron solution.

These two facts show well that we have here to deal with a true chemical phenomenon, and not with a physical action due to capillarity or any other analogous cause.

Having established this distinctive character so easily recognized between the proto sulphide of iron and magnetic pyrites, I commenced a series of comparative trials on specimens of Troilite from different sources. All these specimens placed in the presence of solutions of sulphate of copper, of which I varied both the concentration and the temperature, *proved absolutely inert*. In this respect, therefore, as also in regard to its composition, Troilite, according to my experiments, approaches closely to magnetic pyrites (Pyrrhotine).

It would doubtless be rash to conclude from this its absolute identity with Pyrrhotine, although that identity appears very probable. But the experiments appear to justify the absolute separation of Troilite from the protosulphide of iron, of which it possesses neither the composition nor character, as is easily proved. *Cosmos*, 18th January 1868.—T. O.

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(1) Certain phosphides of iron produce an analogous precipitation.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 2.] 1868 [August.

BLANFORD, W. T., F. G. S., on the Coal Seams of the neighbourhood of CHANDA.

DURING the last few days I have been engaged in examining the coal seams discovered by Captain Lucie Smith, Deputy Commissioner of Chanda, in the neighbourhood of that station. I have the honor to forward the following report upon the prospects of the coal being profitably mined. It will be seen that, although one seam is very promising, some further research is necessary before a decisive opinion can be formed upon this subject. I have had the advantage of Captain Lucie Smith's company during my examination of the coal, and I have received from that officer all the information and assistance it was in his power to afford.

Coal has been found near Chanda in two localities, both upon the banks of the river Wurda. In one of these places a seam is exposed on both banks of the river; in the other, only upon the right bank. The river, it should be remarked, forms the boundary between the Central Provinces and the Nizam's Territories (including Berar)—the left bank belonging to the former.

The more northern of the two localities is about 14 miles due west of Chanda station. It is here that the coal is found upon both banks of the river—the right bank belonging to the south-east or Woon district of Berar. The coal is met with upon that bank in lands belonging to the deserted village of Kumbari. It is exposed in the bottom of a small nulla running into the river; a hole dug in the bed of the nulla showed the coal seam to be between 5 and 6 feet in thickness, the uppermost portion being much decomposed, so that the exact amount of coal is difficult to determine. Below is grey argillaceous sandstone. The dip is about 7° to the west-south-west.

Both above and below the coal seam there are massive felspathic sandstones, good sections of which are exposed in the river. There is a possibility that the sandstone seen north-east of the coal seam, and which appears to underlie it, may be the upper bed repeated by a fault, but there is no trustworthy indication of such being the case. The band of sandstone resting upon the coal can be traced across the country for a considerable distance, and passes just west of the village of Belora. A shaft sunk on the west side of that village would, in all probability, cut the seam, if it extends so far.

The exposure upon the Chanda, or left bank of the Wurda, is at the edge of the river in the lands of Googoos village, and west of the village of Chendoor. There is a bare possibility of the seam being different from that seen on the right bank; but every appearance is in favor of its identity. An excavation made by Captain Lucie Smith, while I was on the spot, gave the following sections:—

1. Coarse white sandstone seen in the river bank, and the same as that on the opposite bank of the river over the Kumbari coal ...	... very thick.
2. White sandy shale with carbonaceous layers	... 2 feet seen.
3. Carbonaceous shale	... 1 foot ,,
4. *Coal* variable ... ... 1 foot 3 inches to	... 2 feet ,,
5. Micaceous sandy shale, cut into to the depth of a foot ...	... bottom not seen.

The dip was the same as on the opposite bank of the river.

The coal in the small hole dug, which was not above 3 to 4 feet across, varied from about 2 feet to 1 foot 3 inches in thickness, and as it has further diminished from 5 feet, or rather more, in crossing the river, a distance certainly not exceeding 250 yards (assuming the two beds to be the same, of which there can, I think, be scarcely any doubt), it appears improbable that the seam can be profitably mined upon a large scale, it being likely that the quantity of coal will be limited.

The quality is only moderately good. Fair samples from the Kumbari portion of the seam and from Googoos analysed in Calcutta by Mr. Tween at the Geological Survey Office, gave the following results:—

	Kumbari.	Googoos.
Fixed carbon	49·5	40·
Volatile	36·0*	43·5
Ash	14·5	16·5
	100·0	100·0

The proportion of volatile ingredients is unusually large,† especially as the coal is from an outcrop, while the fixed carbon, which for steam purposes is alone of any value, is in very small proportion. From a greater depth the quality would be better; but the coal is below the average even of Indian coals.

At Kumbari there is a considerable quantity of iron pyrites scattered through the seam in nodules and strings, which is a drawback. The coal also appears remarkably liable to decompose; blocks which had been dug for about six weeks, and exposed to two or three days' rain, having been broken up into minute fragments. This liability to decomposition is doubtless partly due to the coal having been dug from so close to the surface, and in so unfavorable a spot as the bed of a nulla; nevertheless it appears excessive.

Altogether it appears very doubtful if much use can be made of this seam. For local purposes a considerable quantity of inferior fuel can doubtless be obtained from it. It is possible that it may again thicken to the north and south. This may be tested by sinking shafts or by boring west of the Wurda, on the west side of the village of Belora, and east of the river about 300 yards west of the village of Googoos. I cannot help doubting if the bed extends so far in either direction.

The second locality in which coal has been found is about 10 miles nearly due south of Chanda, and about 1½ miles south of the village of Balarpur. The spot is on the right or Hyderabad bank of the river Wurda, near the village of Sarte, and the bed is covered by the water of the river at all times, except in the hottest and driest weather. At the time of my visit, in the middle of April, owing to some recent showers, the river had risen slightly, and the bed was entirely concealed. A cutting into the bank close by, however, exposed the coal, and a hole was dug into it to the depth of 7 feet, of which the upper 6 feet were coal, and the lowest foot carbonaceous shale. Coal may, of course, recur beneath this. But the sinking with the means at our disposal had become very difficult and slow, owing to the reflux of water, and sufficient had been ascertained to prove the coal of workable thickness, *if constant.*

The top of the seam is not exposed, at least no rock is found overlying, and it is therefore impossible to say whether any of the coal has been removed with the overlying rocks or not. Upon the coal rests an accumulation of alluvial clay forming the bank of the river. All therefore that can be positively stated is, that the bed at this spot is not less than 6 feet in thickness.

As regards quality the upper portion of the seam is, of course, somewhat decomposed, less so, however, than might have been anticipated. The uppermost 3 feet, so far as the state of the coal allows of an opinion, appear to consist of fair coal, but shaley and impure here and there. The lower 3 feet are decidedly superior, indeed one foot at the bottom appears to consist of an unusually pure and bright coal. Taking the seam as a whole, I anticipate

* This gave water 8·0, sulphur ·85.

† The best seam in the Pench Valley, near Chindwara, that of Sirgori, gave on analysis—

Fixed carbon	61·6
Volatile	28·0
Ash	10·4

that it will yield fairly useful fuel for all purposes. The quantity of pyrites appears to be considerable, but not excessive. It is interspersed throughout, and not in nodules as at Kumbari. It is, however, difficult to form a correct estimate of the amount from an inspection of the specimens procured from so near the surface. The seam may be considered as highly promising. But before it can be considered as available for mining purposes, its thickness and quality must be ascertained to be constant throughout a considerable area. It is also very desirable to ascertain whether it recurs on the Chanda side of the river. I regret that I am unable to throw much light upon these points. The concealment of all rocks near the outcrop of the coal is so great that scarcely any indications are afforded even of the general dip, and the few that are met with are somewhat contradictory.

The dip of the seam itself is obscured. The angle is very low—certainly below 5°, and appears to be to the north-east or north, but at the same time to vary. About 200 yards up the river, on the same bank, a large quantity of coarse sandstone is exposed with an apparent general dip to the east of about 5°, but the rock is so excessively false-bedded that its real dip can only be guessed at. Still further up the river, towards Balarpur, there is more sandstone, also with an apparent low eastwardly dip; but at Balarpur the beds are either horizontal or dip to the north-west.

About 300 yards below the coal also, on the right or west bank of the river, sandstone is again exposed, but no trustworthy indication of a dip could be discovered. All around, on both sides of the river, is an alluvial plain, and I could find no trace of rock. The general appearances are in favor of an east or north-east dip. The sandstone seen to the north up the river may underlie, and that seen down the river rest upon, the coal, but this is little more than a guess. If the dip be to the east the coal should be found in a shaft or boring on the left or Chanda side of the river, at a depth not exceeding 50 or 60 feet below the bottom of the bank.

It is extremely desirable that an attempt should be made to find the coal by sinking or boring through the sandstone on the river bank below (south-west of) the outcrop on the Hyderabad side of the river. His Highness the Nizam would doubtless order the necessary exploration if made acquainted with the facts. In sinking upon the Chanda side it is far from improbable that only alluvial clay may be met with to the depth mentioned. In this case it would be well to make deeper explorations further from the river bank, the persistency of the seam can, in all probability, meantime be settled by a few sinkings or borings on the Hyderabad side of the river. Further exploration on the Chanda side, with the exception of one or two shafts on the river bank, would best be deferred until this important question is decided.

Assay yielded the following results for these coals:—

	Balarpur.	Balarpur, 'best part of seam.'
Fixed carbon	51·2	49·9
Volatile	39·0*	42·1
Ash	9·8	7·7

Probable existence of other seams.

The existence of the seams discovered by Captain Lucie Smith renders it probable that others, as yet undiscovered, may exist in the neighbourhood, especially as the rocks are greatly concealed by alluvium. The area occupied by the true coal-bearing rocks of the Damuda series does not, however, appear to be very large; and owing to the superficial accumulations beneath which they are buried, boring must, in all probability, be resorted to in order to explore them. The discovery of the localities already known is clearly due, when the difficulties of the case are considered, to most persevering enquiries and research, and I have no doubt but that the same energetic search, if further prosecuted, will, as at Chindwara, lead to further discoveries.

Still I think it improbable that the neighbourhood of Chanda is equal in mineral wealth to the Pench Valley near Chindwara. As stated above, the area occupied by the coal-bearing rocks appears smaller, and their thickness is less. The far greater facility of communication with the Railway, and the possible future demand for fuel for the navigation of the Godavery, Pranhita and Wurda,† give a great advantage to the Chanda localities, and

* This yielded sulphur ·77, water 4·5. All burn with a strong long-sustained flame and no caking.

† The localities where coal has been found near Chanda are on the navigable portion of the Wurda, and if the proposed works for the improvement of the Godavery navigation be carried out, they will be in direct water communication with the whole of the river.

thinner seams, or inferior coal, than could be profitably mined near Chindwara, might be worked with advantage at Chanda. *Camp; Chanda District, April 20th*, 1867.

During the present season, borings have been carried out close to the town of Chanda itself, and have proved the existence of coal, about 2 feet 6 inches in thickness. The coal is said to be hard, but as no trial of it has yet been made, its quality is really unknown. It is highly probable that this bed will prove to be an extension of the beds seen on banks of the Wurda by Mr. Blanford. A shaft has also been sunk at Googoos, noted above. Up to present date (July) it had been carried down perpendicularly to a depth of 30 feet, giving a section of 16 feet, broken ground; 7 inches, clay; 6 inches, *coal*; one foot shale; 5 inches, *coal*; 5 feet 9 inches shale, hard and firm; and then 9 feet 6 inches, of coal; in which the men were (on the 13th July) still working without any sign of change, the coal improving in quality. All the beds were found to dip at 10° to 11° to the west-south-west, lying conformably one on the other.

These excavations have been carried out by the energetic Deputy Commissioner Captain L. Smith, who has also had the able co-operation of Mr. A. Binnie, F. G. S., Executive Engineer. The results seem to place beyond a question (what from the evidence visible at the surface, Mr. Blanford was inclined to doubt), that the coal beds are continuous, and afford promise of a large supply of fuel. It is highly probable that the two thin seams of coal, with intervening shale, amounting altogether to 2 feet in thickness, represent the bed seen by Mr. Blanford on the left bank of the Wurda, and that this is therefore distinct from that visible on the right bank; the latter being, possibly, the representative of the lower and thicker bed cut through in the shaft noticed above. Mr. Blanford fully pointed out the impossibility of arriving at any sound conclusion in a country so covered as that around Chanda.—(T. O.).

BLANFORD, W. T. Coal near NAGPUR, being copy of a letter to the Secr. to Chief Commissioner, Central Provinces—(dated Camp, Chanda District, 12th February, 1867).

I have just finished the examination of the various sandstone rocks which are found on the edge of the trap area in the Nagpur district, and as the Chief Commissioner will doubtless be desirous to have early information as to the possibility of coal being found in them, I will state briefly the results of my examination.

The sandstone of Taklee and Seetabuldee and all which occurs along the edge of the traps to the south of Nagpur as far as the boundary of the Chanda district belongs to beds of later age than the coal-bearing series. The sandstone hills east of Oomrair consist of beds older than the Indian coal rocks. In neither, I think, is there any chance of coal being found. The sandstones of Kamptee, Sillewara, Bokhara, and all met with west and north-west of those places as far as Kailod, also the rocks of Hootkyree and Chorkyree, and probably the sandstones near Bazargaon, belong to the Indian coal-bearing series, but I can find in them no indication of the occurrence of coal, nor of the rocks, such as carbonaceous shales, which generally accompany coal. Indeed there is a very remarkable and unusual absence of carbonaceous matter throughout; even the plant fossils have everywhere lost every trace of carbon.

By far the greater portion of the beds belonging to the Indian coal-bearing series near Nagpur are concealed by thick alluvial soil, and it is impossible to say whether coal exists among the concealed rocks or not. For the reasons just mentioned, I think it improbable that it does occur, so improbable indeed that I cannot recommend search by boring.

Still if it be thought that, in so important a matter, the question should be definitely set at rest, I would point out the following spots where borings to a depth of 200 or 250 feet would explore rocks not visible at the surface:—

1. Bokhara, north of the little hill just east of the village.
2. Sillewara, north of all the quarries. This bore to be stopped at once if metamorphic rocks are reached.
3. Bhuruthwara, at the village.
4. Soonair, in the river.
5. Kailod, south of village.
6. Agra, near Chorkyree, the Nulla west of the village.
7. Shahpore, north-west of Bheead and east of Bazargaon; at the village.

Geological Notes on the Surat Collectorate, Season 1862-63, by A. B. Wynne, F. G. S.—The Collectorate of Surat lies in the Bombay Presidency on the west side of India between the 20th and 22nd parallels of North Latitude and the 72nd and 74th degrees of East Longitude, Greenwich. Its southern extremity reaches to the Damaungunga river, about 100 miles north of Bombay, and passes between the small maritime Portuguese settlement of Damaun, and a somewhat larger territory called Nuggur Huvellee, about 30 miles to the east, also belonging to the Portuguese. On the west it is bounded by the Arabian Sea, and on the north for some 40 miles by the little river Keem. Beyond the village of Keemchokey the northern boundary becomes irregular, extending, however, generally eastward for 50 miles to the Rajpeepla hills. The eastern boundary of this Collectorate is very irregular: it runs for some 30 miles through the above named hills till it reaches the Taptee river; there it turns to the west with the stream for a few miles, and then strikes off to the south, keeping outside the hilly district called the Daung, and after many bends approaches the sea between it and the Dhurrumpoor country, so that the district becomes of very small width compared with that which it has to the north.

The principal places in the district are the city of Surat and the towns of Bhodan on the Taptee, Turkeesaur and Oolpar in the north, and Nosaree, Gundavee and Bulsar to the south.

General form of the ground.—This district lying, as it does, between the hills forming the northern end of the Western Ghâts range and the sea can only be called hilly in the north-eastern corner, which includes some of the Rajpeepla group. The rest of it consists of one great plain nowhere quite level, in some places undulating sharply, and in others rising into wide, swelling, smooth eminences, and it is here and there at intervals broken by abrupt isolated hills, like those south of Turkeesaur, outliers of the Rajpeepla group; one north of Mota village, a few more on the eastern side of the district, the conspicuous hill of Parneira surmounted by its ruined Mahratta fort, and others at and near Bugwarra. The whole country slopes slightly to the west; it is crossed by numerous streams from the east. And as the tide flows for a considerable distance up the channels of these (in the Taptee, for instance, to beyond Surat), the whole country can have but a small general elevation above the sea probably not more than 150 feet, if so much.

The coast is everywhere low, and for some distance inland in the north part of the district barren, salt and sandy, plains extend. Being thickly populated and much under cultivation the country is only here and there overrun by jungle, which is, however, very dense in some places, chiefly along the streams at the east side of the Collectorate.

In such a country it is difficult to find characteristic features, and yet it has a characteristic aspect produced by the repetition of similarities.

The many undulations of the plains are too slight and too numerous to take any definite direction at a glance, but the larger of them forming the watersheds of the rivers run like the latter more or less east and west; and when the isolated hills take anything of a ridge-like form they run most frequently, like the coast and the neighbouring limits of the hills, more nearly north and south than east and west.

If the plains, however, present few rising grounds as projections they are broken by numerous deep ravines—nullahs and kharries along the courses of the rivers and their tributary streams. These ravines are, of course, deepest towards the sea, but further inland the rivers run between cliffs frequently from 50 to 80 feet in height.

Taken generally the district may be described as flat, with isolated hills in the south, and bordered on the east by a hilly and jungly tract.*

Relations between the form of the ground and its Geological Structure.—These are not so obvious as they at first sight might appear. The reason of this is, apparently, that the limits of the space under description, although embracing a considerable tract of country, are not sufficiently extensive to enable us to generalize.

Certainly as we approach the south the hills are more numerous, and it is ascertained that all the underlying rocks as well as the hills themselves consist of trap. On the east side of the district this is also the case, and glancing at the whole country in the neighbourhood, we find a group of trappean hills (extensions of the 'Western Ghâts' of India) on the east

* Famous for the prevalence of fever at nearly all seasons of the year, and bearing the name of the Daung.

and south, between which and the sea is a wide plain covered to a great depth with cotton soil, alluvium and detrital accumulations, and forming almost the whole of the Surat district. Although the superficial deposits are very thick, the underlying rock occasionally approaches and appears at the surface of the plain, and where it begins to rise almost imperceptibly towards the hills. It is not in all cases found to consist of trap, but in the northern part of the district in the Taptee river and other places, a series of conglomeritic, calcareous, arenaceous and argillaceous, rocks are found dipping at a very low angle westwards, and in some places containing a profusion of nummulites and univalve shells: in others further up in the series they contain large bones, teeth of shark-like fish and vegetable remains as well as other fossils. These rocks have been provisionally termed the *nummulitic series*, and from their very low and sometimes undulating angles of dip, their soft nature and their present position, it seems more than probable that the forces of denudation which must have acted with great power over the whole country reduced the surface of the portion formed of them below that of the harder trappean hills, wearing down these overlying rocks so as to form the basement of the plain. Thus we should expect to find the *nummulitic series* wherever the rock becomes visible in the plains. And this is generally the case; however, large portions of the low ground are so deeply covered by the surface deposits that the rocks beneath are entirely concealed, and as the well known readiness with which trappean rocks yield to the disintegrating action of the atmosphere, &c., may not have differed greatly from that with which the overlying series did so, particularly when, as here, the stratification of both dips in a similar direction at very low angles, it is possible that the line of demarcation between the two formations may be so slightly defined that the place of junction forms no stronger feature in the ground than is traceable here, and is easily concealed by overlying detrital accumulations, although further from the junction where either the *trap* or the *nummulitic series* occupies the whole country *en masse* the characteristic shapes of the ground forming hills in one case, or plains in the other, become very apparent.

The *formations* which occur are—

Recent	Cotton soil. Alluvium and river beds.
Tertiary	Nummulitic series.
?	Trap.

Trap.—The lowest of these formations in geological order is the trap which occupies the eastern side of the district, extending into it from the hilly country to the east, nearly as far westwards as Turkeesaur in the north. Its boundary is concealed by the alluvium of the plains, but it would appear to strike south by west so as to come out upon the sea shore near Bulsaar. It forms part of the great trappean group of Central India, and the Western Ghâts, and precisely as in those precipitous and highly picturesque mountains, it is everywhere found to form part of a regularly stratified series* intersected by numerous dykes of very similar material which are frequently porphyritic.

The trap beds or flows, although all very similar, consist of considerable varieties, ranging from solid basaltic trap to soft shaly-looking amygdaloid, the variously sized cavities of which are filled with zeolites of different kinds, and sometimes by transparent or amethystine quartz. Beds which are locally highly ferruginous are of common occurrence, and in many instances these have a red colour, and weather rapidly away into a rusty soil, but in others the action of the atmosphere appears to have hardened them into a variety of laterite. It is sometimes observed that the upper surface of a bed only has the deep red color as if an alteration had been caused by the overflowing trap resting next upon it.

Concretionary structure is very common among these traps, none within this district were observed to be columnar, if we except a lateritic mass, which will be alluded to further on. No regular order of arrangement seems to obtain among the traps, the different kinds

* This enormous accumulation of trappean rocks, whether we consider its wide superficial extent or its great thickness, which in the neighbourhood of the Ghâts must exceed 3,000 feet, exclusive of the unknown upper portion removed by denudation, may well excite our astonishment. It is perhaps the largest group of stratified trappean materials in the world, and the vents through which these found their way to the surface have never been discovered. The dykes, although in some places numerous, are very insignificant both in number and quantity compared with the rest of the group, and seem quite inadequate to having afforded exit for the bedded traps, whose regular lines of stratification may be traced by the eye for many miles ranging terrace-like along the sides of the Ghâts' mountains with a parallelism to the horizon and each other, which it seems difficult to separate from the supposition of their having been deposited in water.

lying one upon another, and beds passing from one texture to the other without any kind of sequence, but at several places where from the considerations given above we might infer an approach to the upper portion of the group visible in this country, there is a predominance of the red lateritic beds as the trap rocks first become visible in ascending the streams. Connecting these different points of eminence there would seem to be a zone of ferruginous traps either among the highest trap beds of the Surat district or along the border of the Nummulitic series which rests unconformably upon them.

This zone seems certainly to belong more to the traps than anything else. As an instance, however, of what may be a somewhat analogous occurrence, I may mention that at the unconformable junction of the old red sandstone and silurian formations in the interior of the south of Ireland, the silurian rocks over large districts and to a considerable distance from their boundary, but always apparently in consequence of the vicinity of the old red, change from gray to red and are highly ferruginous; in some places containing veins of hæmatite; this ferruginous appearance increases as the unconformable boundary limit is approached notwithstanding any circumstances of dip or strike in the (silurian) rocks of which it is quite independent; and so plainly is it marked that upon observing it I used to know I was approaching the old red boundary. It has generally been attributed to infiltration from the overlying ferruginous red rocks, and as the nummulitics here contain laterite beds near their base similar causes may have produced like results.

The *Nummulitic series* is the next geological sub-division in the ascending order, resting unconformably upon the traps,* and spreading in gentle undulations under a large portion of the district. It consists of a very varied series of beds comprising hard lateritic ferruginous rocks, coarse conglomerates, dull yellow earthy limestone, sandy and clayey beds, and beds of loosely cemented gravelly conglomerate. The following table compiled from various sections will show the general features of the exposed portion of the series with its preponderance of sandy and gravelly beds above and ferruginous ones near the base :—

Conglomerates, sandstones and hard calcareous breccia.
Yellow limestones, sandy and gravelly conglomerates and shales *(Oyster shells* and *Balanidæ).*
Calcareous sandstones, gravelly conglomerates, sandy limestone and shales *(fossil wood, shells and spines).*
Sandy conglomerate, sand layers and ferruginous partings.
Calcareous concretionary clay and pale yellow sandstone *(bone fragments).*
Sandstone and clays (sandstone containing *plant* fragments).
Agate conglomerates.
Limestone (with *Nummulites*).
Stratified ferruginous conglomerates and sandstones and sands.
Stratified ferruginous sandstones, blue clays and variegated beds.
Yellow ochreous sandy clay, bluish and pale lilac clay.
Shales, sands, clays and sandstones.

The above list indicates the general features only, and is not a detailed representation of any one particular succession. Calcareous beds are often met with, but though these here and there become represented by thin bands of limestone, it was only in one locality (the country about Turkeesaur) that this was observed to occur in sufficient quantity to occupy a large space of ground.

From the position of this series it is difficult to arrive at an estimate of its thickness, which must, however, be very considerable, although the angles are so frequently low, for sections with a vertical thickness from one to three hundred feet may be seen in many of the streams. Many of the beds are highly fossiliferous; some are largely made up of *nummulites,* others of the separated valves of *Balanidæ,* some contain a number of univalve and other shells with which the teeth of sharks, segments of the carapace of a turtle, and of large ribs

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* The evidence for this assertion is but small, only one junction, or rather very near approach to a junction, is seen. Here the rocks have the appearance of unconformity, but in other places where the two formations occur at short distances from each other there is reason to believe that the ground is traversed by faults. The deduction is made from the occurrence of conglomerates in the upper series containing agates derived apparently from the traps, also from local appearances and observations upon the same rocks made at a distance from this district.

and portions of other bones as yet undetermined, have been found. From the evidence of the fossils, a '*Parisien*' age has been assigned to this series of beds.*

The *alluvium* includes all the deposits which so extensively occupy the district, concealing and covering up the above-mentioned rocks over the low ground and forming the mural precipices which edge all the larger streams at a little distance from the sea.

It is almost universally composed of a fine light coloured argillaceous loam seldom pebbly or gravelly, and always formed from the decomposition of the local rocks. It sometimes presents lines of stratification, but more frequently is quite amorphous—its only characteristic being that like other Indian deposits of the kind, it contains numerous concretions of impure carbonate of lime (kunkur). Its quantity and depth are its most striking features, and the mass of it appears to be older than that forming the flats along the large rivers, but they pass so insensibly into each other that it is impossible to distinguish one from the other; its surface is frequently moulded into hillocks and vallies over small spaces bearing a very great resemblance to those of the Irish drift, but whether these are the results of mere atmospheric or other aqueous action it is difficult to say.

Associated with this alluvium and generally passing beneath it are numerous beds of recent conglomerate with a calcareous cement, but even of these it is not possible to speak with certainty as to age, for they appear to be in process of formation at present along parts of the coast, and their consolidation might take place at any time; some, however, are old enough to have been cut through by, and to form in places the beds of, the rivers.

Cotton Soil—covers the alluvium over many large tracts of the country, indeed it overlies it almost everywhere upon the open slopes as well as on the flats and in the hollows. It is often of considerable depth, presenting the usual desiccation cracks, but without any circumstances to throw additional light upon its source or formation. It seems in this country at least to be the ultimate result of the decomposition or recomposition of an alluvium largely made up of trappean materials; its colour may be due to decayed vegetation, or to iron or both, and its light loamy or compost-like character to the changes from wet to extreme drought, its great exposure to the influence of the air by means of the deep cracks, and its frequent disturbance by ants, &c., great quantities of whose excuviæ it must contain.

We will now proceed to give some detailed notes of the rocks in various localities, commencing at the north end of the district.

In the country lying about Oolpar the rocks proper may be said to be wholly invisible. The country is covered by alluvium, and only changes its aspect along the sea shore where a belt of salt marsh and barren sandy ground washed by the high monsoon tides forms the coast. The *kharries* or streams for long distances inland are all salt, and efflorescences of the salts of soda and (?) alumina exude from the ground. In the Keem river at Elao and above that village near Sahol, there are hard white calcareous sandstones and breccias, some of which are worked into stones for hand mills at the last named villages. They belong to the upper part of the *nummulitic series.* Near Obah further up this stream the alluvium is worn through by the river exposing yellow limestone and soft yellow clay with ferruginous bands. These limestones occur again in the country to the north-east. More yellow limestone and sandstone with calcareous concretions and ferruginous layers occur: some of these beds are conglomeritic in places and in others strangely cellular, with a knotted and angulo-concretionary

* The following is a rough list of fossils procured from these beds, in the Taptee river, a little below Bhodan, near the junction of a small stream called the Rhea. They have been identified by Dr. F. Stoliczka:—

Rostellaria Prestwichii, D'Orb.
Terebellum, sp.
Cerithium, sp.
Cypræa (Cypræovula) elegans, Lam.
Natica longispira, Leym.
Conus, sp. (near *C. brevis*, but thinner).
Trochus, sp. (like *T. mitratus*, Desh.).
Pholas, sp.
Pecten Hopkinsi, D'Arch. and Haime.
,, *Favrei*, D'Arch.
,, *corneus*, Sow.
Vulsella legumen, D'Arch. and Haime.
Ostrea Flemingi, D'Arch.
,, *lingua*, Sow.
Hornera, sp. (near *H. verrucosa*, M. Edw.).
Echinanthus, (fragments).
Cidaris, (spines).
Fragments of other *Echinidæ*.
Stylocœnia Vicaryi, M. Edw. and Haime.
Trochoseris (?)
Trochocyathus Vandenbeckii, M. Edw. and Haime.
Nummulites perforata, D'Orb.
,, *Brongniarti*, D'Arch.
,, *exponens*, or *spira*, (probably both).

The 'bone fragments' were portions of ribs, &c., not in a state sufficient for identification.

structure. The alluvium in the river banks is here only about 15 feet thick. Conglomeritic and calcareous beds are seen occasionally from this to Kuthoora near Keemchokey, where one of the latter contains several shells, portions of spines, &c. Calcareous beds occur again in the Keem river, about 3 miles above Keemchokey.

Near Turkeesaur is a considerable exposure of light buff and gray nummulitic limestone and agate conglomerate. A low range of hills rises near this town and stretches southwards to the Taptee; they are formed of ferruginous or lateritic beds intercalated between agate conglomerates, and having a low dip to the west, they pass beneath the limestone just mentioned, which, however, is traceable along their flank and re-appears in the Taptee river at the end of the range, being let down by a fault to a lower level, but preserving its westerly dip, and seen to be overlaid again by another band of laterite.

From this eastwards the country, which now becomes hilly, forming part of the Rajpeepla group, is all occupied by the traps, amygdaloids, &c., already described in general terms and possessing no variety except a curious pale flaggy band which extends from near Ooskir to Monjelao. The Taptee river at Bhodan and above it for many miles exposes the traps which are seen to have a very general but low and undulating dip to the west, and to be intersected by numerous dykes of dark green-gray porphyry and solid trap. From Gulla to Palree the rocks of the nummulitic series overlying those of the Turkeesaur neighbourhood are seen in the banks of the river; they consist of fine gravelly conglomerates, calcareous beds, and fine smooth pale gray mudstones. The latter were not found to be fossiliferous, but the others contain many bones, fossilized timber, univalve and bivalve shells, the teeth of sharks, and plates of the carapace of turtles. The finest locality for fossils, however, is in the limestone let down by the fault, near a ruined village on the north bank of the Taptee, about 3 miles east of Gulla.

In the neighbourhood of Surat city the country is covered with the fine brown alluvium, which extends all over this part of the district and eastwards for many miles beyond Mota along the valley of the Taptee.

An isolated hill, rising to a height of about 100 feet from the alluvium 4 miles north-north-east of Mota, is formed of compact and brecciated laterite of very similar character to that occurring east of Gulla; its beds appear to undulate nearly horizontally. A small quarry in the east side of the hill exposes a soft purple and white mottled rock like a decomposed and lateritified amygdaloid, in which occur sub-angular lumps of red hæmatite.

More red lateritic beds occur interstratified with the traps in the river due south of Mota and below Bordolee. Eastward of this the country rises and undulates, and the usual kinds of gray traps and amygdaloid are seen along the streams and protruding from the surface of the ground.

The Poorna river exposes the traps at Muhoowa, and above and below this place they are of the usual kinds with some reddish beds, and the last seen as the river enters the alluvium near Kohureea are associated with red lateritic beds.

In the Umbeeka river which flows from Wulwarra past Gundavee the traps are also exposed, and likewise a quantity of recent conglomerate. This river affords a good example of the character of all the streams in this country, the banks wide apart formed sometimes of alluvial cliffs and sometimes sloping into the stream, the bed of which is often rocky, and in the dry weather contains but a rivulet, here trickling among the stones and again forming still deep pools. Several instances of the manner in which the traps yield to the abrading forces occur, amongst which alternations of hard and soft beds (as at Nagthera near Poonea), frequently present most varied outlines.

North of Gundavee at a bend in the Poorna river there is a quantity of red lateritic rock, which from its peculiar prismatic jointing assumes a columnar appearance when viewed in one direction. It seems to dip to the north at 15°, and a few yards above it in this direction with a similar dip are some red shales and a band of loose conglomerate or coarse sandstone a foot thick which probably belongs to the upper series. Unfortunately very little of these rocks is seen projecting from the alluvium, but although the want of a good section is felt, there is little doubt that the boundary of the two groups passes near the place and perhaps includes the lateritic rock in the Nummulitic series.

At a little more than 100 yards north of this spot parts of the skulls and several bones of two human skeletons were found exposed in the alluvial cliff on the left bank of the river,

at a depth of several feet from the general surface of the ground and 18 inches below the local surface, which in this place seemed to have been excavated by rain.*

From this neighbourhood the alluvium rapidly becomes thin to the east, and although it does not possess any marked natural boundary, it is seen to grow narrow towards the south, the trap country approaching the coast and the plain becoming dotted with hills all formed of trap. High ranges of hills are seen away to the east and south beyond the limits of our district and trap rocks occur in all the rivers. Some of the isolated trap hills rise to a considerable height. That at Parneira, the most conspicuous among them, roughly measured by a barometer is at the summit nearly 200 feet above the plain at its base, but it looks much higher. The trap of this country does not differ from that stretching along the whole of the east side of the district, and although it is not to be seen everywhere, there is no want of evidence to show that the whole country is composed of it. Dykes are perhaps more numerous than in several other parts of the district: where the Railway crosses the Damaun river and where there are a great number, their general direction approximates to north and south.

From near Teetul on the coast west of Bulsar and re-appearing at intervals to the south, is a growing deposit of recent conglomerate formed of the materials of the beach cemented by carbonate of lime; it is stratified, the strata dipping at a low angle seawards, and the dead shells which it contains have been in many instances completely fossilized and replaced by carbonate of lime even when they happened to be a large variety of *Murex*, whose shell is very thick; but in few instances, if any, was the interior of the shell filled up by either sand or the cementing matter.

ADDITIONAL OBSERVATIONS REGARDING THE CEPHALOPODOUS FAUNA OF THE SOUTH INDIAN CRETACEOUS DEPOSITS, by *Ferd. Stoliczka*, Esq., Ph. D., Palæontologist, Geol. Survey, India.

Since the completion of the volume on the *Cephalopoda of the cretaceous rocks of Southern India*,† at the end of 1865, several additional observations have been made regarding this portion of the fauna. No fresh materials have been procured, but having had last year the opportunity of examining, in London, Prof. Forbes' original collection, made by Messrs. Kaye and Cunliffe, and also in different European Museums a large number of other species with which Indian Cephalopoda have respectively been identified, I have obtained additional information of various kinds. Some of this is very important, inasmuch as it throws a new light upon the determination of the species, requiring alterations in the names, &c.; it appears, therefore, desirable that these changes should be noticed at an early date. The observations must be considered as a supplement to the volume on the Cephalopoda, already published.

NAUTILIDÆ.

NAUTILUS, *Auctorum.*

NAUTILUS DANICUS, *Schlotheim.*—(Ceph. l. cit., p. 24 and 208).

Nautilus delphinus, Forbes (Trans. Geol. Soc., Lond., 1846, VII, pp. 98 and 99), which was described from two specimens in Messrs. Kaye and Cunliffe's collection of Pondicherry fossils, must be considered as identical with the above species. Forbes' figure on p. 99 is reduced to one-half the natural size, being taken from a larger specimen, which is, however, very much corroded at the surface. In consequence of this erosion the outline of the septa became rather different and the thickness of the whorls has decreased. Both the specimens and also some others in our collection appear to have had originally the whorls somewhat more flattened laterally than typical *Naut. danicus* usually have them, but there are again in our collection some other specimens which fully agree with Sowerby's original figure in Trans. Geol. Soc., Lond., 1840, vol. V, pl. 18, figs. 4-7. Another apparent distinction of

* There appeared to be no trace of a burial ground on the bank of the river here, and the lower extremities pointed in the direction in which the stream runs, but as the natives of India are often buried near wherever they happen to die, while some castes bring dying people to the rivers, it is thought more safe merely to record the fact, than to build any geological theory upon so questionable an occurrence.

† Palæontologia Indica, Vol. I, 1866.

the two original specimens of Prof. Forbes is the small number of septa, one of the specimens having 10 and the other 12 of them, while of two specimens of *N. danicus* from Rügen, in the Geol. Soc. collection, one has 16 and the other 18 septa. I have compared all our available specimens of this species, and I find that the number of the septa appears greatly to vary. Inflated specimens usually have a smaller number of septa, as few as 10 in one circuit, but this number always increases in somewhat greater proportion with the size of the shell; more compressed specimens usually have 16—20, but occasionally as many as 24 septa, these being arranged much closer to each other the more they approach the body whorl.

AMMONITIDÆ.

AMMONITES, *Auctorum.*

AMMONITES BLANFORDIANUS, *Stoliczka*, Ceph. l. cit., p. 46.

This species is closely allied to some of the compressed varieties of *Am. varians*, but always distinguished from it by a much narrower back, higher and serrated keel; the septa are in both species almost identical, but appear to be a little less serrated in the Indian fossil.

Am. varians and *Coupei* stand in about the same relationship to each other as do *Am. Mantelli* and *Am. navicularis.*

AMMONITES ROSTRATUS, *Sowerby; Am. inflatus*, Sow., Ceph. l. cit., p. 48. This last name must be replaced by the former, inasmuch as it is not only more characteristic, but also has priority, the species having been first figured and described under the above name.

AMMONITES SIVA, *Forbes*, Ceph. loc. cit., 39. The terminations of the saddles of this species are phylliform, exactly as in the *HETEROPHYLLI*, for which Suess proposed the name *Phylloceras.*

AMMONITES REMBDA, *Forbes*, Ceph. loc. cit., p. 63.

One of Forbes' specimens of *Ammonites Durga* is a young shell of this species, having the upper layer of the shell removed and the keel therefore obsolete. The specimen figured by me (loc. cit., pl. 71, fig. 5) as a young specimen of *Am. Durga* also belongs to *Am. Rembda.*

AMMONITES IDONEUS, *Stoliczka*, Ceph. loc. cit., p. 64.

Another specimen apparently of this species has been subsequently found in the greyish, siliceous sandstone from near Andoor. It is about the same size as the one figured on plate 36, but has no trace of tubercles, the transverse ribs becoming, however, somewhat obsolete at the centre of the back. It is also slightly irregularly coiled at the inner edge of the umbilicus, giving the shell an appearance of a young *Scaphites.*

AMMONITES VICINALIS, *Stoliczka*, Ceph. loc. cit., p. 84, pl. 44.

It is, as formerly stated, very doubtful whether this species is distinct from *Amm. Saxbii*, Sharpe. I have compared the original of the English fossil, which in general character fully agrees with the Indian species, merely differing from it by a larger number of intermediate shorter ribs and a more squarish section of the whorls, while all our specimens of *Amm. vicinalis* are conspicuously compressed towards the back. Until more and better preserved specimens of the English species have been found they cannot be pronounced to be identical; the outlines of the lobes are in both the same.

AMMONITES DISPAR, *d'Orbigny*, Ceph. loc. cit., p. 85.

I have seen a specimen of this species in a collection of fossils of the Hanoverian cretaceous deposits in the Museum of the Mining Institute at Berlin.

AMMONITES GUADALOUPÆ, *Römer*, Ceph. l. cit., p. 90.

Römer's original specimen, which is in the University collection at Bonn, is rather badly preserved; it has the umbilical tubercles somewhat more distantly placed from the suture, than in most of our specimens, but this does not appear sufficient to be a specific distinction between them.

AMMONITES ORBIGNYANUS, *Geinitz*, Ceph. loc. cit., p. 92.

Young specimens of this species have a few small, sharp tubercles at the edge of the umbilicus, and the lateral ribs being strongly flexuous on the outer half of the whorls become

almost obsolete on the inner one. Our fossil perfectly agrees with Geinitz's original specimens in the Museum at Dresden.

AMMONITES SUBOBTECTUS, *Stoliczka,* Ceph. loc. cit., p. 96.

In Sharpe's collection, presented to the London Geological Society, there are one large specimen and three fragments of *Am. obtectus.* The row of tubercles in the middle of the back is distinctly traceable, though it sometimes appears to become obsolete; the transverse ribs are present in the same number as the lateral ones; the distinction mentioned (loc. cit., p. 97) as existing between the European and the Indian fossils must, therefore, be retained.

Ammonites Cunliffei, Forbes, Ceph. loc. cit., p. 97, is a *Scaphites,* and will be noticed subsequently.

AMMONITES PAVANA, *Forbes.*

1846. *Ammonites Pavana,* Forbes, Trans. Geol. Soc., Lond., VII, p. 110, Pl. VII, Fig. 5.

Amm. testa compressa, lateraliter applanata, moderate umbilicata, costis flexuosis prope marginem dorsalem sub-tuberculatis, longioribus et brevioribus alternantibus, ornata; dorso obtuso, paullulum rotundato et lateraliter compressiusculo.

Height of outer whorl	:	the whole (considered as 1·00)	... ... 0·50.
Width of umbilicus	:	ditto ... (,, ,, ,,)	... ... 0·29.
Thickness of whorl	:	its height (,, ,, ,,)	... ... 0·42.

Prof. Forbes' original specimen, though not very perfect, appears to be distinct from all other *Ammonites,* as yet known from the South Indian cretaceous deposits. It has the appearance of a young *Scaphites*; but for this the shell is too regularly coiled, and besides most of the species of that genus have the ribs at the back generally recurved, not bent (or at least not so strongly) anteriorly. The lateral ribs are in *Am. Pavana* strongly flexuous, double curved, becoming gradually thicker towards the edge of the back, where they are provided with small tubercles; obsoletely continuing across the back, which is obtusely rounded; each long rib alternates with one or two shorter ones.

The specimen appears to be from the *Arrialoor sandstone* near *Pondicherry.*

AMMONITES GANESA, *Forbes,* Ceph. loc. cit., p. 106.

Amm. Soma, Forbes (Trans. Geol. Soc., London, 1846, VII, p. 102, pl. VII, fig. 7) must be considered as a synonym of the above species, the name having been proposed for a young specimen of the same. Forbes' remark on the tablet of the original specimen in the London Geological Society's collection was already to that effect.

AMMONITES INDRA, *Forbes,* Ceph. loc. cit., p. 112.

Amm. Garuda, Forbes (Ceph. loc. cit., p. 149, pl. 74, fig. 5) is, remarkably enough, only a young specimen of the above. There are three specimens of this species in the London Geological Society's collection; all show the furrows on the back. The young shell has really a very different aspect from the old one, inasmuch as the whorls begin to increase very rapidly in width as soon as the specimen has attained a certain size. The specimen figured as *A. Garuda* has a markedly large umbilicus. The outlines of the septa are quite the same as those of *Am. Indra.*

AMMONITES VELLEDÆ, *Michelin,* Ceph. loc. cit., p. 116.

Amm. Nera, Forbes (loc. cit., p. 106, pl. 8, fig. 7) is only a young specimen of the above European species.

AMMONITES KOLOTURENSIS, *Stoliczka,* Ceph. loc. cit., p. 127.

Amm.? indicus, Forbes (loc. cit., p. 114, pl. 8, fig. 9) may be a fragment of a whorl of the above species, but the original is so much mutilated that it is impossible to form any decisive opinion. The fragment is valueless in point of identification.

AMMONITES DIPHYLLOIDES, *Forbes,* Ceph. loc. cit., p. 119.

The specimen described by me, loc. cit., p. 120, pl. 59, fig. 12, under the name of *Amm. Yama,* Forbes, is identical with the above species. It has the shell partially preserved, and the transverse furrows consequently not traceable; the difference then pointed out as existing between the division of the sutures was due to the small diameter in which the sutures were observed on that specimen. The original specimen of *Amm. Yama,* Forbes, is the same which I have referred to *Amm. Beudanti,* which now must stand under the former name, being distinct from the European fossil.

AMMONITES VAJU, *Stoliczka*, Ceph. loc. cit., p. 132.

Prof. Geinitz in Dresden directed my attention to a few specimens in his Museum, being apparently identical with those described under the above name, but on the other hand not easily distinguishable from *Amm. peramplus.* The relations of the two species are indeed remarkable, and *Amm. Vaju* would only seem to be a compressed variety of *Amm. peramplus,* still the distinctions pointed out by me (loc. cit., p. 132) are remarkably constant; none of our specimens of the former had the distinct furrows of the latter developed; besides this the direction of the ribs in both species also is somewhat different. Until more specimens of the present form have been found the specific distinctions must be retained.

AMMONITES YAMA, *Forbes,*

1846. *Amm. Yama,* Forbes, Trans. Geol. Soc., London, 1846, VII, p. 107, Pl. VII, Fig. 4; not *idem*, Ceph. loc. cit., p. 120.
1865. *Am. Beudanti,* Brong., Stoliczka, Ceph. loc. cit., p. 142.

I am indebted to my friend Prof. Hebert in Paris for having directed my attention to the most constant and distinguishing character of the European Gault species, *Amm. Beudanti,* Brongn., as compared with our Indian species, which in general differs from the former by having the whorls less high compared to their width, laterally a little more convex, along the back not contracted, and the umbilicus slightly larger in proportion. There are, however, of the European fossil occasionally specimens to be found, which are extremely closely allied to our species, and only differ by a scarcely traceable greater compression of the whorls (compare Pictet's figures in Pal. Suisse, 2nd Series). The most important difference between the two species lies in the form of the outline of the septa. Those of *Amm. Beudanti* are comparatively broader, less high, and the laterals gradually diminish in size as they approach the umbilicus, on the edge of which the sixth lateral saddle is situated; only one or two very minute ones are present on the umbilical slope. In our Indian species the outlines of the septa have higher, more ramifying saddles and lobes, and the third lateral saddle lies on the edge of the umbilicus, there being at least three additional and very oblique saddles situated on its sloping side. All the lobes of *Am. Beudanti* are arranged in an almost straight line, while those of the present species form a distinct curve. The number of the septa is tolerably well marked in d'Orbigny's figure in the "Pal. Francaise."

Prof. Forbes' original specimen of *Amm. Yama* is a young shell of the present species, and I therefore retain the older name, which appears the more justifiable, as the specimen which I have previously (loc. cit., p. 120) described under that name has proved to be only a somewhat abnormal form of *Amm. diphylloides.*

AMMONITES SACYA, *Forbes*, Ceph. loc. cit., p. 154.

The species described by Coquand from the cretaceous beds of Algiers under the name of *Amm. Pauli* is probably a young shell of this species (Geol. and Pal. Province Constantine, 1862, pl. 35, figs. 1-2).

SCAPHITES.

SCAPHITES CUNLIFFEANUS, *Forbes, sp.*

Ammonites Cunliffei, Forbes, Ceph. loc. cit., p. 97.

Scaph. testa lateraliter compressa, costis ad intervalla fortioribus, flexuosis, numerosis brevioribus ac tenuioribus interpositis ornata, primis ad marginem umbilicalem et dorsalem acute tuberculatis; anfractibus junioribus regulariter involutis, ultimo antice paulo-extenso, dorso subconvexo.

The original specimen figured by Forbes in Trans. Geol. Soc., London, 1846, VII, pl. 8, figs. 2 a and 2 b, is unmistakably a *Scaphite;* it has the last whorl somewhat more produced at the umbilical line, than is shown in the figure. The shell is flattened laterally, ornamented with numerous flexuous ribs, which terminate in sharp tubercles at the edge of the back and of the umbilicus, the former being slightly rounded; the sides of the umbilicus are perpendicular.

The young shell has the lateral ribs more straight, and the tubercles on the umbilical edge almost obsolete (see pl. L, fig. 3).

The outline of the sutures, as represented in fig. 3 c, pl. 50, is also characteristic of a *Scaphite,* there being only the first and second lateral lobe present, while the auxiliary lobes and saddles rise suddenly in an oblique line towards the umbilical suture.

SCAPHITES SIMILARIS, *Stoliczka.*

1866. *Scaphites æqualis*, Sowerby, Stoliczka, Ceph. loc. cit., p. 167, Pl. LXXXI, Figs. 4-6.

I have compared in the British Museum the original specimens of Sowerby's *Sc. æqualis* and *obliquus* as recorded in that author's Mineral Conchology; the figures are in general correct. The inner whorls of both the species are usually of the same thickness and not to be distinguished from each other, but the form described as *Scaph. æqualis* has on the last whorl the transverse ribs less numerous, thicker, the sides somewhat more flattened, and the general form is usually a little longer than in *Scaph. obliquus.* Both are very closely allied, and, when examining numerous specimens in Sharpe's collection and others in Paris and Dresden, the frequent occurrence of the two forms together in the same beds and the same localities so very much struck me that I thought they very probably only represent different sexes of the same species. Still so long as the distinctions, formerly noticed, exist, and no other direct proof in favour of their specific identity can be produced, we cannot but retain them as distinct forms under separate specific names.

The species which I have noticed as *Scaph. obliquus* (Ceph., p. 168) is in every respect identical with the European form, but the other which I have identified with *Sc. æqualis,* and for which I now propose the name *Sc. similaris,* is distinct from it, though it undoubtedly must be regarded as a representative species. It differs from *Sc. æqualis,* by having the first whorls less involute, flattened at the sides, almost smooth, and by the want of the peculiar projection in the umbilical space at the base of the body-chamber, which projection is distinctly traceable in both the European species. *Scaph. similaris* also appears to be a more compressed form than *Sc. æqualis.*

ANISOCERAS,* *Pictet,* Ceph. l. cit., p. 170.

ANISOCERAS RUGATUM, *Forbes,* Ceph. loc. cit., p. 178.

Anisoceras sub-compressum, Forbes (Ceph. loc. cit., p. 179, pl. 85, fig. 7) is based upon a fragment of the above species. Forbes' figures of *Anis. rugatum, sub-compressum,* and *indicum,* are taken from fragments which do not exactly agree with the specimens in the London Geol. Society's collection, so far as the form of those specimens is concerned, but there are fragments of all the species represented in the collection. Some of the specimens determined by Forbes as *Anis. sub-compressum* belong to *Anis. indicum.*

TURRILITES, *Lamarck,* Ceph. loc. cit., p. 184.

TURRILITES PLANORBIS, Forbes, Ceph. loc. cit., p. 185.

This name has most likely been applied to a small cast specimen of *Amm. Sacya,* Forbes, of which I found several small specimens, but I have in this single instance not succeeded in procuring Forbes' original specimen, from which fig. 5, pl. 9, in the Trans. Geol. Soc., London, was taken.

TURRILITES, *Conf.,* BRAZOENSIS, *Römer,* Ceph. l. cit., p. 189.

Römer's original of *Turr. Brazoensis* is very like our fossil, but it shows a slight difference in the direction of the ribbings connecting the tubercles; still their identity is very probable; neither of the two respective fragments are, however, sufficiently preserved to give a direct proof of this assertion.

HAMULINA, *d'Orbigny,* Ceph. loc. cit., p. 192.

HAMULINA SUBLEVIS, *Stoliczka,* Ceph. loc. cit., p. 193.

I have seen specimens of this species in the National Museum at Prague; they were collected from the lower beds of the Bohemian cretaceous deposits at Korizany.

Summing up the most important changes regarding the different species, it will be observed that *Ammonites Pavana,* Forbes, has been newly added to the list of the Cephalopoda;

* My friend Prof. Gabb writes word, under date of June 2nd, 1868, Philadelphia, that he has a new form, intermediate between *Anisoceras* and *Ancyloceras.* He also suggests a new generic name for species like *Ptychoceras Forbesianum,* distinguished by having two links, but it seems to me that our materials of good specimens of *Ptychoceras* are hardly sufficient to support any essential changes in the nomenclature of these and others allied Ammonitoid forms.

the species formerly described as *Amm. Beudanti* is different from the European fossil, and has to stand under the name *Amm. Yama,* while the specimen formerly noticed under that name is identical with *Amm. diphylloides.* Several other species formerly described by Forbes under the names of *Amm. Soma*, *Amm. Nera*, *Garuda*, and others have been found to be identical with other known species; the specific name *Amm. inflatus* has to be replaced by that of *Amm. rostratus ; Amm. Cunliffei* is a *Scaphite,* and the species noticed as *Scaph. æqualis* has to be changed to *Sc. similaris*, n. sp.; and last *Anisoceras sub-compressum* has been found identical with *Anis. rugatum.*

These changes reduce the number* of Cephalopoda from 148 to 146, three species having been identified with others, but one was newly added; the genera represented are, *Belemnites* with 3 species, *Nautilus* with 22, *Ammonites* with 91, *Scaphites* with 4, *Anisoceras* with 10, *Helicoceras* with 1, *Turrilites* with 6, *Hamites* with 2, and *Hamulina* with 1, *Ptychoceras* with 3, *Baculites* with 3. The list of the 38 species identical with those of Europe and other countries must be reduced by one, for though *Amm. Yama* and *Sc. similaris* must now be considered respectively as distinct from *Amm. Beudanti* and *Sc. æqualis,* I have recorded the occurrence of *Hamulina sublevis* in the Bohemian cretaceous deposits.

LEAD in the district of RAEPORE, Central Provinces.—In the month of May last, a specimen of lead ore was received from the Deputy Commissioner of Raepore, with a request for information as to its nature and value. It was stated by Captain Twyford to be found extensively in the hills between Raepore and Balaghat, and also near Chicholee, where there is a Dâk Bungalow on the great eastern road. On examination it proved to be galena in crystalline masses imbedded in green fluor-spar forming a vein in quartz. On assay only a trace of silver was found to be associated with the lead. The impossibility of forming any idea of the commercial value of a metallic vein or lode from a hand specimen was also noticed.

Subsequently very similar specimens were forwarded by Colonel J. E. Gastrell, Deputy Surveyor General, together with copies of letters from Mr. R. B. Smart, Revenue Surveyor, who had collected these himself on the spot. He describes the locality thus: 'The hills in which the ore is found are situated in the lands of Khyragurh and Nandgaon, and three miles to the west of Chicholee Dâk Bungalow, near the village of Raneetalao, and Nandga. The hills consist of large masses of quartz imbedded in black earth. The metal runs through the quartz in veins and crusts.' Mr. Smart considered it to be not galena, but the tersulphide of antimony.

These better specimens enabled us to cupell a larger portion of the ore, but with the same results; the amount of silver present, although appreciable, is not sufficient to be of any practical value. There is no antimony present. Fluor-spar is more abundant than was at first thought, and the colour is quite as frequently of a rich purple as greenish.

From Mr. Smart's description the specimens sent appear to have been derived from loose blocks, but there can be no question that they formed part of a regular vein, which must have existed where these loose blocks were derived from. And in all probability this was at no great distance from the spot where they were found. It will be desirable to trace out this lode, and prove its extent or value. It looks, both as to rock and gangue, decidedly promising.—*July* 1868.—(T. O.)

COAL IN THE EASTERN HEMISPHERE.—The vast importance of any local supplies of coal in the eastern seas, both as bearing on the development of navigation and commerce, and as tending to relieve the intensity of the strain on the limited resources of Great Britain, from which hitherto most of the supply has been derived, renders peculiarly interesting at the present time any trustworthy information regarding the various sources from which coal may possibly be procured, their exact locality, probable extent, and the character and value of the fuel obtainable. We have therefore abstracted, as briefly as possible, a paper

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* Those like *Amm. Soma, Amm. Nera, and pavana,* etc., were not included in my paper published in Quart. Journ. Geol. Soc., London, 1865, vol. XXI, p. 408.

by Cuthbert Collingwood, M. B., on the Formosa, Labuan, Siberia, and Japan coal, which is printed in the Quar. Jour. Geol. Soc., London, No. 94, May 1st, 1868.

Formosa coal district is near Kelung, in north-east corner of island. Mines, about one mile to east of town, on the hills bordering on Quar-se-Kau Bay, are reached by boat. Leaving the boat you pass a range of red sandstone hills, dipping about 16°-17° to south-east. All the country around Kelung is of red sandstone, the weather-worn outcrops forming the depression in which the coal appears to have been deposited. The workings when visited consisted of two small caverns at right angles to each other in the coal-seam, which was, at outcrop, 2½ feet thick. It rested upon a thin bed of stiff whitish clay, and was covered by a bank of rubbly clay, 40 to 50 feet high. Workings were nearly on the level and of very primitive kind. No machinery is used, no shafts are sunk; the coal is picked out and removed in small baskets to boats, by which it is conveyed to the harbour and is deposited in the coal-stores, where it is not in any way protected from the weather, and rapidly deteriorates. The mines are exclusively worked by Chinese. Coal is of recent formation, and lies over the sandstone.

Another thin seam of indifferent coal was seen near the town of Skiddow, about the middle of this part of the island, 'over which was a bed of stiff clay, abounding in large 'oyster-shells, seven or eight inches long, of a species (probably the recent *Ostrea Canadensis*), 'which I have seen brought to Canton in vast numbers for the purposes of lime-making.'

The Kelung coal is light, burns very rapidly, and gives out a great heat, so that it readily sets the funnel on fire. It is extremely dirty, produces a vast number of blacks of a soft and soiling character; the flues get rapidly very foul, requiring frequent cleansing. It leaves 50 per cent. of ash: its cheapness being therefore doubtful.

The *Labuan* coal-field is in a dense jungle, where the coal crops out conspicuously not far from the sea. The coal district is chiefly composed of a soft yellow sandstone, dipping 30° north by east. There are several seams of coal; the lowest is 11 feet 4 inches thick, but in quality this is not the best seam. The coal roof is a stiff blue clay, not fire clay. The highest seam is 4 feet 6 inches in thickness; the second 2 feet 9 inches; the third is 3 feet 9 inches; the fourth 11 feet 4 inches. Above this fourth seam there are 8 fathoms of grey shale in which fossil shells are occasionally found. There are two shafts, one to the first seam, and the other 45 fathoms deep. A third is being put down, which will go to 100 fathoms. There are also 7 or 8 level workings. There is great difficulty in getting labour. Nominally the Company have 600 of various nations, but only 300 are at work. The present out-turn is 80 tons per day. This is conveyed down a tramway, less than a mile in length, to the coaling pier. With more labour it is said 200 tons per day could readily be raised.

Labuan coal is better than that from Kelung, heavier, close grained, tolerably clean, very free from sulphur, and forms but little clinker. It burns fast, gives out much heat, flames issuing from funnel often extending 6 or 8 feet, and endangering the rigging. It produces a large quantity of soot, which renders everything filthy. It would seem to be like the Kelung coal, a *lignite*. Mr. Low, of Labuan, states that he has found in "the stiff "clay roof of some of the seams impressions of leaves in very perfect preservation identical "with those of trees at the present moment growing in the jungle."(?) There are in the coal itself frequently found tears of 'pure Dammar resin', and the Dammar pine is still a common tree. On one occasion a mass, 6 lbs. in weight, was found. It has a remarkable tendency to occur in veins.

Petroleum is found in immediate vicinity of coal districts, both at Kelung (Formosa) and at Labuan. The Chinese also have an idea that Formosa is rich in gold; gold has been found. There is a petroleum spring not far from the mines; in Labuan a pathway to the spot in the jungle has been cleared, but no workings have been undertaken. There are other springs in the neighbourhood.

Russian coal.—This is at Possiette on the coast at south point of East Siberia, and at Dui on the island of Saghalien, at the head of Castries Bay. The latter is a convict settlement; the coal is worked by the convicts, and used solely for the Russian ships of war. This coal is small, of excellent quality, presents longitudinally a conchoidal, and transversely a cubic fracture, like Welsh coal, producing a moderately dense dark brown smoke. Steaming qualities said to be equal to Newcastle coal, and owing to its caking qualities it would probably burn very well mixed with any small Welsh coal, too small to burn by itself. Amount of ash, cinder, and soot 20 per cent.

The Possiette coal has a vitreous fracture, more like English Cannel coal, is very bituminous, and burns quickly; leaves a large residue of whitish brown ash, with a moderate quantity of clinker; deposits soot much more than Newcastle coal.

The Dui coal appears to be a lignite.

In *Japan* also several kinds of coal occur, only small quantities are obtained, and the Daimios will not allow it to be sold for public use, so that not much is known regarding the qualities of the coal. There are five kinds, known as Gorio, Hirado, Korkora, Emakbodkh, and Korgah, which appear to possess good qualities. And several others which are very inferior, forming an immense quantity of clinker, and unfit for steaming purposes, though no doubt valuable for domestic use.

The Korkora coal is of two qualities; one inferior, dirty brown, showing thin red layers when broken and conchoidal in fracture. The better kind is bright, clean and hard, liable to form clinker, so that it was found desirable to increase the apertures between the fire-bars with the ordinary tubular boilers. It resembles Sydney coal in appearance, and appears to have a waste (ash, soot, and clinker) of about 30 per cent.

Korgah coal recently brought to Nagasaki is very similar in appearance and quality.

Emakbodkh coal shows clayey layers, and conchoidal laminations of a white calcareous substance, either carbonate or sulphate of lime. This scaly appearance is characteristic. It burns well, though with much smoke.

Hirado coal is either hard or soft. The soft kind cannot be used for steaming, as it is reduced to powder by being shaken up in the bunkers, otherwise it is a good coal. Of the harder coal there are two varieties; one abounds in earthy matter and silica, producing a vitreous glaze on the clinker, and the other is light in appearance, resembling Welsh coal, and contains about 72 per cent. of carbon. It has a cubical fracture. Consumption is about ¼ more than best Welsh coal, with which, however, it might be advantageously mixed.

The best of the Japanese coals is the Gorio; a clean hard cubical coal, like Welsh, and with 73 per cent. of carbon. Only small quantities, however, have been brought to Nagasaki; and the mine has fallen in in consequence of heavy rains, so that some time will elapse before the old workings can be made use of.

A remarkable coal has been brought in small quantity from Ivanai, in the north part of Nipon, where there appears to be a large mine of it. The Daimio to whom it belongs is not friendly to foreigners, and the coal is therefore procured with difficulty. The coal is worked by the Japanese. It is a clean highly bituminous coal, and will burn with flame in the light of a candle. "It appears like the rest to be a lignite." Quar. Jour. Geol. Soc., London, Vol. XXIV, p. 98.—(T. O.).

METEORITES.—Through the kindness of Dr. M. Hörnes, Director of the Imperial Mineral Cabinet, Vienna, we have received a valuable addition to our series of meteorites. This is a very fine specimen of the fall which took place near Pultusk in the vicinity of Warsaw on the 30th of January in the present year.

Through the Austrian Consul General in Warsaw Dr. Hörnes had procured a specimen, the third largest which fell. This was divided into three parts for examination, and of these three Dr. Hörnes with his usual liberality has sent to me the second in size. It weighs 6oz. 398grs. The largest specimen which fell was in possession of a private party; the second largest went to the Imperial Mineral Collection in St. Petersburgh.

The fall occurred on the river Narew, about half way between Pultusk and Ostrolenka, about 36 English miles north-east of Warsaw. The stone sent to Vienna was actually picked up in the village of Sielč Nowy.

Dr. W. Haidinger, in a brief notice of this fall (read to the Imperial Academy of Sciences at Vienna on 12th March 1868) says: "From the various reports which have appeared, it is clear that we have here again to deal with a truly magnificent phenomenon, beginning as a shooting star, afterwards appearing as a fireball of half the diameter of the moon, then vast detonations, at last a fall of meteoric stones, over a tolerably large extent of ground."

'The stone received in Vienna was perfect, that is, it was covered on all sides with a distinct crust, but at the same time, judging from its shape, it was truly an angular fragment of a rock-mass, which burst long prior to its reaching our atmosphere. It was a somewhat conical fragment, rather sharply angular in one direction, where the sides, 2 to 3 inches broad, meet at an angle of about 60°. In the other directions, the three sides meet at angles of from 90° to 105°.'

'The surface is rather uniformly coated with a crust of about $\frac{1}{150}$th of an inch in thickness. This black crust is dull, fine grained, and on all planes covered with the well known and characteristic round shallow impressions. The stone was about 4 inches long, 3 broad and 2 thick. One side was rough, the other more even, before the incrustation, but both are similarly incrusted. Even at the sharp angles, no molten edges are traceable which would indicate that the stone had passed through the atmosphere only in a given direction.'

'The fresh fracture of the stone, and especially the cut and polished surfaces, showed that the stone undoubtedly belonged to the group of falls indicated by Partsch, and including Eichstädt, Barbotan, Bielaja Zerkow, Timochin, Zebrak, Gross-Divina, to which must since be added Pokra (Bustee). These are all grey, more or less dark coloured, locally brown, with more or less globular portions distinguished from the rest of the mass by a nearly black colour with much finely divided iron, a little pyrites, and probably troilite. The Pultusk stone is very similar to that from Gross-Divina. Its specific gravity is 3·660 (Schrauf.), which indicates the large proportion of iron it contains. The average specific gravity of the group was determined by Partsch as 3·55 to 3·70.'

The stone would belong to the third class, *sporadosidéres*, and to the second sub-division of that class, *oligosidéres*, of Mr. Daubrée's classification.—(T. O.).

DONATIONS TO THE MUSEUM.

Specimens of the following minerals have been presented by David Forbes, Esq., F. R. S., &c., &c.

Titanoferrite, with hornblende	Krageroe, Norway.
Eisen-nickelkies (original typical form)	Espedalen, ditto.
Nickeliferous Pyrrhotine	Ditto ditto.
Bismuthine, with Pyrites	Sorata, Bolivia.
Gersdorffite	Dolschau, Hungary.
Phosphorite	Estremadura, Spain.
Native Bismuth, with Bismuthine	Sorata, Bolivia.
Native Silver	Thunder Bay, Lake Superior, Canada.
Staffelite	Staffel, Nassau.
Tyrite	Hamfernyr, Norway.
Titanoferrite, with Aspidolite	Krageroe, Norway.
Gadolinite, with black Yttrotitanite	Ytterby, Sweden.
Hornblende	Krageroe, Norway.
Tourmaline...	Ekeland, Norway.
Chlorapatite	Tambillos, Chili.
Rutile	Krageroe, Norway.
Cerite	Riddarshyttan, Sweden.
Alvite	Arendal, Norway.
Native Alum	Smyrna.
Scapolite	Krageroe, Norway.
Cryolite	Greenland.
Moroxite	Canada.
Titanic Magnetite	Norway.

FROM THE ROYAL SCHOOL OF MINES, LONDON.

Large mammillated mass of Hæmatite	Whitehaven, Cumberland.
Three specimens of fibrous hæmatite	Ditto ditto.
Specimen of ditto showing tendency to fracture into paraboloids	Ditto ditto.
Specular Iron, crystallized, with quartz crystals, on hæmatite	Ditto ditto.
Copper pyrites, in mica schists (vein)	Fahlun, Sweden.
Veinstone, showing deposits of Galena, Zinc-blende, calcite, &c.	Przibram, Bohemia.
Asphalt, from great Pitch-Lake	Trinidad.
Tin ore with topaz	Durango, Mexico.
Fahlerz, crystallized with quartz	Saxony.
Celestine, from new red marls	Bristol.
Quartz crystals, group of	Dauphine.
Tinstone	Huel Spearne, Cornwall.
Tinstone, two large specimens	Huel Owles, ditto.
Pyromorphite	Wheatley, Mine, Pensylvania.
Cerusite	Ditto ditto.
Anglesite	Ditto ditto.
Chromo-molybdate of Lead	Ditto ditto.
Copper glance	Monte Catini, Tuscany.
Antimoniate of Lead	Spain.
Graphite, Alibert mines...	Irkutsk, Siberia.
Zincite, with Franklinite	New Jersey.
Mica	Cornwall.
Magnetic Iron	Dannemora, Sweden.
Ditto ditto	Bispberg, ditto.
Red iron ore	Langbau, ditto.
Ditto ditto	Nassau.
Schistose red iron ore	Ditto.
Copper Pyrites	Ditto.
Malachite, on brown iron ore	Ditto.
Green carbonate of copper in gossan	Dillenburg, Nassau.
Pyrolusite	Nassau.
Cyano-nitride of Titanium, artificial, from Iron furnaces ...	Workington, Cumberland.
Fibrous gypsum	Nottingham.
Pectolite	Ayrshire, Scotland.
Carbonate of Lead	Zillerfeld, Hartz.
Scheelite	Caldbeckfells, Cumberland.
Titanite, in Granite	Norway.
Sulphur	Valais.
Calcite	Strontian, Argyleshire.
Green fluor spar	Cumberland.
Plumbo-calcite	Leadhills, Lanarkshire.
Vanadinite	Wanlock-head, Dumfriesshire.
Scapolite	Norway.
Beryl	Gweebarra Mts., Donegal.
Garnet, with Idocrase	Dunglow, Donegal.
Wulfenite	Bleiberg, Carinthia.
Rutile, in quartz	Perthshire.
Specular iron ore	Elba.
Manganite	Hartz.
Baryto-calcite	Alston Moor, Cumberland.
Barytes, in clay iron ore	Workington, Cumberland.
Actinolite	St. Gotthard.
Zinc-blende	Cumberland.
Texasite, on chrome iron ore	Texas, Pensylvania.
Green talc	St. Gotthard.

Sanidine in Trachyte	Drachenfels, Rhine.
Green Pyromorphite	Cumberland.
Selenite with sand, from the basement bed of London clay, Upnor, near Rochester	Kent.
Purple fluor spar	Cumberland.
Brown fluor spar, with carbonate of iron	Allenheads, Northumberland.
Albertite	Nova Scotia.
Quartz crystals	Snowdon, Wales.
Phosphorescent fluor spar, from East-pool mine, near Redruth	Cornwall.
Lithomarge, Restormal iron mine, near Lostwithiel ...	Ditto.
Fibrous Carbonate of Copper, with pyrites	Ditto.
Gun Flints, showing effects of intense heat on flints, from the Tower of London, after the great fire of October 31, 1841.	

From J. CALVERT, ESQ., C. E.—Specimens of Schorl from Beerbhoom, and of Gold soil from Nicaragua.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 3.] 1868 [November.

General results obtained from an examination of the Gastropodous fauna of the South Indian cretaceous deposits, by Ferd. Stoliczka, Ph. D., F. G. S., Palæontologist, Geol. Survey, India.

The second volume of the "*Palæontologia Indica*," recently completed and published, contains the descriptions of 237* species of Gastropoda from the cretaceous deposits of South India. The fauna is very rich and varied, though probably not quite so extensive as might have been expected relatively to the large number (146) of Cephalopods which were described from the same beds. Still as many species, only represented by specimens in the state of casts, have been laid aside, further examinations of the ground will no doubt furnish large additions.

Taking a general review of the fauna of the Gastropoda, it will be interesting to point out some of the more important families and genera which were found to be represented.

The first family which in this respect is deserving of special attention is that of the *HELICIDÆ*, represented by four species, three of which belong to the genus *Angystoma* and one to *Macrocyclis*. Nearly all are found in the uppermost beds, stated by Mr. H. F. Blanford to have been deposits in shallow water. The extremely rare occurrence of land shells in cretaceous rocks increases the interest connected with those four species, especially as they mostly belong to types which are still found living in the same or neighbouring districts.

The sub-order Prosobranchia counts 174 species, of which the larger number belongs to the Siphonostomata Ctenobranchiata. Among the *ALATA* the genus *Pugnellus*, which up to the present has only been found in cretaceous rocks of North America, has yielded three very interesting species; it is in the recent fauna represented by species like *Strombus gallinula*. The *CYPRÆIDÆ* are remarkably numerous, being represented here by almost as many species as were previously known from cretaceous deposits in general, in which, as a rule, they are very rare. Among the types described are some which belong to *Cypræa* proper, several to *Luponia* and others to *Aricia*, *Epona*, &c. From the large number of *CYPRÆIDÆ*, as also from that of the *VOLUTIDÆ*, the peculiar forms of the *MURICIDÆ* and of the *PURPURIDÆ*, I draw the conclusion that the genera and species belonging to these families were already during the cretaceous time somewhat more numerous in the eastern than in the western hemisphere, or, in other words, that the present distribution of a portion of the Gastropoda, at least, was already indicated at that remote period.

The *OLIVIDÆ* are represented by a species of *Dipsacus*, the *CASSIDIDÆ* by a very interesting small species of *Oniscia*, the *PLEUROTOMIDÆ* by *Cythara* and *Pleurotoma*, the *CONIDÆ* by that peculiar form *Gosavia*, intermediate between this and the next family. Of the *VOLUTIDÆ*, 18 species are described belonging to the genera *Scapha*, *Melo*, *Ficulopsis* (n. gen.), *Fulguraria*, *Athleta*, *Volutilithes*, *Lyria*, *Volutomitra*, *Mitreola* and *Turricula*.

* Including some new specific forms, which on account of the imperfectness of the specimens have not yet received specific names, though acknowledged as distinct from other known species.

Of the MURICIDÆ I would particularly mention *Pollia Pondicherriensis*, because it so much recalls the form of our common, recent *Pollia melanostoma*, and a species belonging to the genus *Trophon*.

The TRITONIIDÆ have representatives in species belonging to *Hindsia*, *Tritonium* and *Lagena*; the BUCCINIDÆ in those of *Nassa* and *Pseudoliva*; the PURPURIDÆ in *Tudicla*, numerous species of *Rapa* and one of *Rapana*. Not less interesting are also two species of *Trichotropis* and five species of the CANCELLARIIDÆ, representing the genera *Cancellaria*, *Euclia* and *Narona*. No TEREBRIDÆ have occurred, and the PYRAMIDELLIDÆ offer no peculiarities, nor are they very rich in species or genera.

The CERITHIIDÆ mostly belong to marine sub-generic types, the absence of the very large number of POTAMIDINÆ, occurring in the deposits of the Alpine-Gosau formation, being remarkably conspicuous as one of the most important differences between the two faunas. The same applies to the MELANIIDÆ, their absence in Southern India being equally due to the apparent want of brackish or fresh water deposits, so far as they are known at the present. The TURRITELLIDÆ have yielded five forms identical with European ones, *T. multistriata* being probably the best known, *T. nerinea*, *nodosa*, *affinis* and *Neptuni*. The rest of the species peculiar to the Indian deposits do not differ in general character from European types. Of the SCALIDÆ three out of four are identical with European species. Of the VERMETIDÆ two interesting species have been referred to a new genus *Tubulostium*, being very characteristic for the Ootatoor beds, which are the lowest of the series. Of the LITTORINIDÆ, the occurrence of which in cretaceous rocks was always disputed, six different species have been met with. Of the RISSOIDÆ I may draw attention to two rather large species of *Rissoa*, one smooth *Rissoina* and three species of that peculiar genus *Keilostoma*, differing from *Rissoina* by the great thickness of the apertural margins. The NATICIDÆ are characterized by the usual large number of species belonging to the genus *Euspira*; three genera, *Naticina*, *Velutina* and *Amplostoma* of the VELUTINIDÆ also deserve specially to be noticed.

When speaking of the family NERITIDÆ, the UMBONIIDÆ, TURBINIDÆ and TROCHIDÆ, &c., I had occasion to remark that most of the recent so called sub-generic forms are already to be found during the cretaceous period. Some of the generic types are very interesting and new to the fauna, as, for instance, *Velates*; *Teinostoma* and *Vitrinella*; *Oxytele*, *Gibbula*, *Euchelus*, *Cantharidus*, *&c.*

The PLEUROTOMARIIDÆ are not very varied in genera, but one species of the peculiar type *Leptomaria* (*L. indica*), is very common, occurring almost through all the successive groups from the lowest to the highest; it greatly resembles several of the European forms.

The OPISTHOBRANCHIA are also worthy of notice, being represented by 24 species; these belong to *Actæonina* (2), *Actæon* (6), *Trochactæon* (3), *Bullina* (2), *Bullinula* (1), *Avellana* (4), *Ringinella* (1), *Ringicula* (2), *Eaptycha* (3) and *Cylichna* (1). This unusually large number of species of that sub-order is the more interesting, as the recent species are far from common shells. The genera *Trochactæon*, *Avellana*, *Ringinella* and *Euptycha* are chiefly cretaceous forms, and therefore in comparison with the present fauna of very great importance. *Actæonina* is one of the oldest genera, but I believe there are a good number of species of recent shells which ought to be transferred to that genus. Of the DENTALIIDÆ, being the only representatives of the PROSOPOCEPHALA, merely four species of the genera, *Dentalium*, *Antale* and *Fustiaria* (n. gen.) were recorded.

After this general review of the fauna I may now enter upon the distribution of the species in the different groups which, beginning with the lowest, are the *Ootatoor*, *Trichinopoly* and *Arrialoor* in the Trichinopoly district, and the *Valudayur* and *Verdachellum* groups near Pondicherry. These last two are equivalent to the first and third named one, respectively. Geological details respecting these groups and their fauna will be found in Mr. H. F. Blanford's Report in the IVth Volume of the Memoirs of the Geological Survey of India. The present remarks regarding the distribution of the species of Gastropoda will therefore be very general.

The 237 species of Gastropoda, described from the cretaceous deposits of South India, divide themselves into the different groups, thus: 113 species are peculiar to the Arrialoor group, 59 to the Trichinopoly and 36 to the Ootatoor; 20 species are common to the Trichinopoly and Arrialoor groups, 4 to the Ootatoor and Trichinopoly, none, however, with sufficient certainty to the Ootatoor and Arrialoor solely. Only five species, *Fulguraria elongata*,

Ampullina bulbiformis, *Gyrodes pansus*, *Solariella radiatula* and *Leptomaria indica* are common to all the three divisions of the deposits. The Gastropodous fauna of the different groups is therefore tolerably well defined, the distinction between the Ootatoor and the Arrialoor groups being especially prominent. The large number of species common to the two higher groups is principally due to the uncertainty of the geological boundary between them. When this point has been more satisfactorily settled, it may show that an equal distinction exists in the Gastropodous fauna between them, as does between the two lower groups. All the species occurring in the Arrialoor group belong to such genera as are now commonly found living in shallow water, while many of those of the Ootatoor group are littoral forms, living on rocky coasts or on coral reefs.—The fauna, as a rule, is purely marine, and there is a remarkable absence of the *POTAMIDINÆ*, of the *MELANIIDÆ* and others which are very characteristic for some of the beds of the Alpine cretaceous deposits. The comparison of our rocks with those of the Alps only applies, therefore, to the purely marine fauna. The Arrialoor beds were probably deposited over a large, very slightly undulating ground in from 2-10 fathoms of water, but at some distance from the coast.

In point of comparison of our fauna with that of other countries I must direct attention to the following table, giving a list of those species which are also found elsewhere :—

No.	Name of Genus and Species.	Geological position. In India.	Geological position. Not in India.	Remarks.
1	Alaria Parkinsoni, Mant.	Oot. and Trich.	Gault and Green sand, (Cenomanien).	
2	„ papilionacea, Goldf.	Trich. and Arr.	Turonien	(Middle Plæner).
3	Cypræa Kayei, Forbes, (Globiconcha ovula, d'Orb.)	Trich. and Arr.	Senonien.	
4	Pleurotoma subfusiformis, d'Orb.	Trich. (Arr.?)	Turonien.	
5	Fulguraria elongata, d'Orb.	Oot.? Trich. and Arr.	Cenomanien and Turonien.	
6	Fasciolaria rigida, Baily	Trich.	Middle cret. of Sth Africa	(Probably Cenomanien).
7	Neptunea rhomboidalis, Zekeli	Arr.	Turonien	(Gosau-deposits).
8	Tritonidea Requieniana, d'Orb.	Trich.	Turonien.	
9	Trichotropis Konincki, Müll.	Trich.	Senonien near Aachen.	
10	Nerinea incavata, Bronn	Oot.	Turonien	Gosau and Transylvania.
11	Cerithium inauguratum, Stol.	Trich. and Arr.	"Craie pisolitique near Paris.	I have observed these two species in Prof. Hebert's collection.
12	„ Arcotense, Stol.	Arr.	Ditto.	
13	„ trimonile, Mich.	Arr.	Gault and Grès verts, (Cenomanien).	
14	Turitella affinis, Müll.	Trich.	Senonien near Aachen.	
15	„ Neptuni, Münst.	Trich.	Turonien	(Middle Plæner).
16	„ nerinea, Röm.	Oot.	Senonien	(Upper Plæner).
17	„ nodosa, Röm.	Oot.	Cenomanien	(Lower Plæner).
18	„ multistriata, Rss.	Trich. and Arr.	Turonien	(Middle Plæner).
19	Scala (?) Clementina, Mich.	Oot.	Gault.	
20	„ subturbinata, d'Orb. (Haidingeri, Binkh.).	Arr.	Senonien of Maestricht.	
21	„ striatocostata, Müll.	Arr.	Senonien near Aachen	
22	Burtinella concava, Sow.	Arr.	Chalk (Turonien).	
23	Rissoina acuminata, Müll.	Arr.	Senonien near Aachen.	
24	Euchrysalis gigantea, Stol.	Trich. and Arr.	Cretaceous beds in Sth. Africa.	Probably Cenomanien.
25	Ampullina bulbiformis, Sow.	Oot., Trich. and Arr.	Turonien beds of the Alpine cretaceous deposits.	Probably also occurring in Texas.
26	Euspira rotundata, Sow.	Arr.	Chalk (Turonien).	
27	„ lirata, Sow.	Arr.	Turonien.	
28	Ziziphinus Geinitzianus, Rss.	Trich. and Arr.	Turon. beds of Germany.	
29	Solariella radiatula, Forbes, (Trochus glaber, Müll.).	Oot., Trich. and Arr.	Senonien near Aachen.	
30	Avellana elongata, Guér.	Oot.	Cenomanien.	

Of these 30 identical species, forming very nearly one-eighth of the entire fauna, 10 species occur in the Senonien, 12 in the Turonien, 4 in the Cenomanien (including 2 species from the South African deposits); 1 species is common to the first and second, 1 to the second and third, and 3 are quoted from the Gault, 2 of which, however, are also found in the Cenomanien. Applying these results in detail to the groups distinguished by Mr. Blanford among the South Indian cretaceous deposits, it will be found that they do not correspond exactly. Thus, species which in Europe occur in the Cenomanien are in India occasionally found in the Arrialoor beds, not as would be expected in the Ootatoor beds only; and again there are Senonien and Turonien species found in the Ootatoor as well as in the Trichinopoly beds. As a rule most of the species from our Arrialoor beds are identical with those from the Senonien; but there appears to be an equal difficulty experienced in India in separating the Arrialoor and the Trichinopoly group, as is felt in Europe in distinguishing properly between the Senonien and the Turonien. The general conclusion, therefore, derivable from the examination of the Gastropoda regarding the age of the South Indian cretaceous deposits is that they *represent only the beds above the Gault*, that is, the *Cenomanien, Turonien and Senonien.*

It is possible that the Ootatoor beds represent the Cenomanien, but the number of fossils obtained from these beds is, in one respect, comparatively as yet very small; in other respects the boundaries between this and the other groups may not have been sufficiently worked out. It appears more justifiable to regard the Trichinopoly beds as the representatives of the Turonien, and (as already stated) the Arrialoor as those of the Senonien. Stratigraphically this tri-division has also great probability.

When reviewing the Cephalopoda of the same rocks (Quart. Jour., Geol. Soc., Lond., 1865, p. 407, etc.), I have stated that the largest number of the identical species of Cephalopoda occurs in Europe in the middle cretaceous strata and especially in the Gault; thus I placed the lowest beds of our South Indian cretaceous rocks as equivalents of the Gault. After having gone over the Gastropoda I found that no Gault species were represented, and conferring with some of my friends at home on this point, Prof. Hebert specially directed my attention to several species of the Cephalopoda which are strictly speaking not typical Gault fossils. I had already occasion to mention* that the identification of *Am. Beudanti* (now *Am. Yama*, Forb.) was found incorrect; but several other species which undoubtedly appear to be identical with European fossils, like *Nautilus elegans*. *N. sublævigatus*, *Am. rostratus*, *Am. Rotomagensis*, *Am. Candollianus*, *Am. naviculáris*, *Am. Mantelli*, *Am. peramplus*, *Am. Timotheanus* and *latidorsatus*, *Turrilites costatus and Bergeri* and others, are such species as pass from the Gault into the Cenomanien and the Grès verts. Prof. Hebert† is of opinion that the true Gault beds must be considered as the uppermost group of the Neocomien or lower cretaceous series, all the beds above being included in the upper cretaceous series. There appears to be a relation of several of our species to such Gault species as *Am. Beudanti, serratus, lautus, denarius, splendens* and to some Neocomien forms, but, on the other hand, the numerous *Cristati* and *Ligati* of our rocks are strongly marked upper cretaceous types. The fauna of the Gault is undoubtedly an intermediate one, and possibly when the stratigraphy of the rocks has been better studied many corrections in points of identifications, at present doubtful, may be made. Some of the species like *Nautilus pseudo-elegans* and *Neocomiensis*, and *Am. Rouyanus* and *Velledæ* I am still unable to distinguish satisfactorily from the typical Neocomien species; the number of these species is, however, so small that they cannot outweigh the other facts which would place the cretaceous deposits of South India higher in the series.

Considering, therefore, that most of the so-called Gault species of our Cephalopoda are equally common in the Cenomanien, and that the Gastropoda have not yielded any undoubted Gault forms, I believe I am more justified in stating that the South Indian cretaceous deposits only represent the *upper cretaceous strata, beginning with the Cenomanien.* The larger number of representative species were found to agree with the Turonien, which is a very wide spread formation, though its limits must be considered rather different from those given to it by d'Orbigny. I have reason to suppose that the present statement regarding the age of our cretaceous deposits will also be supported by the examination of the

* Records Geol. Surv., India, I. pt. 2, 1868, p. 35.

† Bull. Soc. Geol., France, 2d ser., t. XXIV, p. 323, etc.

Pelecypoda, especially the various *Inoceramus*- and *Hippurite*-types. Thus the original notion of representatives of Neocomien beds in South India more and more loses support, as already pointed out by me in the first volume of the "Palæontologia Indica."

In conclusion I should like to draw attention to a parallel of our cretaceous deposits with those of Bohemia, Saxony, North Germany, etc.; this parallel being indeed a very remarkable one. Dr. Gümbel, who has lately (Sitzb. Gesellsch. Isis, Dresden, 1867, p. 72, etc.), devoted a little time to the study of the Bohemian and Saxon cretaceous deposits, states that they generally begin with a kind of fresh-water deposit containing numerous plant remains, and being sometimes represented by a coarse conglomerate, both filling up cavities in the older rocks, which in many instances are metamorphic or crystalline. Immediately above these plant beds follows the series of Quader- and Plæner-beds, the oldest of which are characterized by *Am. Mantelli*, *Inoceramus striatus*, *Ostrea biauriculata*, *Exogyra columba*, etc., as Cenomanien or the Upper Greensand of English Geologists; the highest beds are the equivalents of the upper chalk with *Inoceramus Cuvieri* and *Crispi*, *Rhynchonella octoplicata*, etc., or Senonien. Dr. Gümbel consequently acknowledges an upper, middle and lower Plæner, which may approximately be called Senonien, Turonien and Cenomanien. Dr. Schlönbach, in a very valuable paper, printed in the Official Report of German Naturalists, etc. (Hanover, 1865, p. 160, etc.), expressed similar opinions on the French equivalents of cretaceous beds in Hanover. Zittel, in his admirable work on the Bivalves of the Gosau-deposits (Denksch. Akad., Wien, XXV, 1866, part. II, p. 174, etc.,) enters upon the question of parallelism of those deposits with others in great detail and corroborates the opinion of most of his predecessors that they principally represent the Turonien and the Senonien. Were I to give at this early stage of examination of the fauna an opinion regarding the parallelism of our South Indian cretaceous rocks, I could, as I stated, only compare them with those of North Germany (Aachen, Saxony, Hanover) and Bohemia, but it is impossible to say which of our beds exactly correspond to the Cenomanien, Turonien, and so on; probably the parallel must remain only a general one. To the Gosau-deposits our Trichinopoly and Arrialoor beds appear to form a correlate. What characterizes the Cenomanien of our beds are the Cephalopoda; these are, however, very scarce in the Gosau-deposits. Those lately described by F. v. Hauer have fully the character of Cenomanien species.

There is one point which deserves special attention during any subsequent examination of the ground of the South Indian cretaceous deposits, and this is respecting the plant beds, which underlie all the undoubted cretaceous rocks. Some time ago the Geologists, engaged in the survey of the Madras Presidency, have sent numerous plants and a large number of bivalves, etc., from these strata in the neighbourhood of Sripermatoor. A few small Ammonites belong to the Dentati group, but they are insufficiently preserved for identification. Of bivalves there is a large number of species belonging to *Leda*, *Yoldia*, *Tellina*, *Psammobia*, *Lima*, *Pecten* and others; all forms with a remarkably thin shell and the allies of which are at present usually found living on sandy ground in from 8-10 fathoms of water. Several exhibit a resemblance to species from the cretaceous rocks of Trichinopoly, but *none* appear to be specifically identical. At another locality, fragments of an *Inoceramus*, which belong to a flattened ribbed species like *I. mytiloides*, have been found with the same plants. Of the plants there have been several species (*Palæozamia Cutchensis* and *acutifolium*, and a *Dyctyopteris?*) recognized as identical with those from the Rajmahal beds and again with those found associated with the jurassic Cutch fossils. Thus this would distinctly prove that the South Indian plant beds below the cretaceous rocks are jurassic. I cannot express the slightest opinion on this matter, but in pointing out the parallelism existing between the Indian and North German cretaceous beds, the similar structure of those whitish clay plant beds underlying, in both countries, the above formation appeared to me deserving of marked notice. Special attention must at any subsequent examination be devoted to tracing out the relations of those plant-bearing beds to the cretaceous beds of the Trichinopoly district.

September, 1868.

NOTES on route from POONA to NAGPUR, *viâ* AHMEDNUGGUR, JALNA, LOONAR, YEOTMAHAL, MANGALI and HINGUNGHAT, by W. T. BLANFORD, F. G. S., &c.

Almost throughout the entire route the rock is trap.

Poona to Ahmednuggur.—Leaving Poona the traps between the Moota Moola and Bheema rivers present but few peculiarities. They are the usual stratified amygdaloids, more or less compact, with some bands of ashy, or of basaltic varieties. Dykes are scarce, and very small, if they occur at all.

The beds are nearly, if not quite, horizontal. There is an apparent very low dip to the south-west not amounting to 1°.

The hills east of Wagoolee appear to be formed of beds absolutely horizontal. Upon their top, which is quite flat, is a plain of cotton soil, cultivated in places, which must have resulted from decomposition of the trap.

Crossing to the north bank of the Bheema, the traps have the same low dip. The country is an undulating plain, and the flat hills which dot it near the Bheema disappear entirely further on. Cotton soil occurs everywhere; it is more sandy near the river where there is alluvium in places.

Beyond Koondapoor the plain is traversed by streams which have cut valleys, with steep sides and more or less flat bottoms. The whole country has very much the appearance of a plain formed by marine denudation, through which plain the streams have cut. But the general uniformity of the surface is doubtless due to one hard bed of trap. Where this has been cut through by a stream, the rocks beneath are easily removed till another hard bed is met with, and this generally forms the base of the valley.

Over a large area the principal bed is seen to have a very low easterly dip, not nearly amounting to 1,° at the most $\frac{1}{3}$ to $\frac{1}{2}$ a degree. It is a very flaggy bed.

About a mile east of Bangungaon the beds appear to roll over and to dip at a very low angle to the south. This is at the watershed between the Bheema and the Goor rivers. A more rubbly bed of trap comes in decomposing into round boulders. There is an apparent undulation in the beds hereabouts, but at such extremely low angles that the appearance may be due to the lenticular form of beds or accidents of denudation.

Thence to the Goor at Seroor the road descends gradually, passing hills more or less rounded in form, composed of the softer beds of the trap.

The hills immediately north-east of the Goor are much rounded and the bedding inconspicuous: it is, however, nearly, if not quite, horizontal.

Near the 24th milestone from Ahmednuggur the road comes up upon high ground. The beds around are well seen, and are nearly horizontal. Indeed, the apparent low dips may be due to the lenticular form of the beds. An instance of this is seen on a hill about one mile south of the road just where the latter attains the summit level. One of the strata composing the hill thins out rapidly, so that the terrace formed by its upper surface dips east, and that formed by its lower surface dips west.

Still there is here, as before, the appearance of a very low westerly dip. The country as far as Soopa is an undulating plain with scattered rocky flat-topped hills. The traps as usual consist of alternations of hard basaltic beds with softer ashy strata.

From Soopa eastwards the same horizontal stratification prevails. About the 11th milestone from Ahmednuggur there is an apparent low southerly dip. Thence the country falls gradually to the broad and nearly flat valley of the Sina river.

From Ahmednuggur the road runs north to the base of the flat-topped hills which enclose the Sina valley. In these hills the traps appear to be perfectly horizontal. Thirteen miles from Ahmednuggur at the Seeor Ghât the road suddenly descends a scarp 500 feet high to the nearly flat valley of the Godavery. On the side of the road towards the top

of the scarp a fine section of traps is exposed, and the following beds are seen in descending order. The thicknesses given are merely approximate :—

1.	Compact basaltic trap weathering into rounded boulders, and divided by numerous irregular jointing planes of a yellow brown colour; thickness considerable; upper surface not seen	
2.	Soft ashy purplish amygdaloidal trap, about	20′
3.	Hard crystalline compact basaltic trap, with but little jointing, containing agate and quartz in parts; this bed is softer and less compact, about	50′
4.	Soft grey amygdaloid, containing horizontal layers of agate, and kernels of agate and of stilbite or heulandite. Some kernels also contain a black micaceous mineral; *none of the kernels are surrounded by green earth.* This bed has a thin layer of red bole on the top: about	15′
5.	Very amygdaloidal soft grey trap, half composed of small nodules of agate and zeolite all covered with green earth; surface of bed irregular	20′ to 30′
6.	Thin parting of red bole ... ... 3″ or	4″ to 1′
7.	Amygdaloid similar to 5, but containing fewer nodules, and these also covered with green earth	10′ to 15′
8.	Purplish very amygdaloidal bed. Kernels covered with green earth. The rock mixed here and there with large patches of felspar porphyry ?	

From below this the section is less distinct, all the beds to the bottom of the Ghât being much decomposed at the surface: the majority are amygdaloids—felspar porphyry (basaltic trap with large tabular crystals of glassy felspar) occurring in places. The beds appear thin where seen along the hill side, generally 10 to 15 feet each. The upper hard bed appears to have preserved the hills and given them their flat top.

For some distance below the Ghât while traversing the gently undulating plain of the Godavery much trap appears at the surface; beyond that distance black soil alone is seen in general, the trap only cropping out in rises here and there. This is the case throughout as far as the Godavery. The cotton soils appear greyish on the higher parts of the country, darker in the hollows, and they are much mixed with sand and salts in the neighbourhood of the river.

On the banks of the Godavery near the villages of Moonghee and Pyton, there is a considerable thickness of brown clay above, generally abounding in kunkur, and evidently a river deposit. Below this is gravel, chiefly of fragments of agate and of a zeolite (apparently natrolite). In places this gravel is united by a calcareous cement into a concrete. The upper kunkuriferous clay is frequently obliquely laminated, the laminæ dipping, as a rule, though not invariably, down the stream. Trap rarely appears below Moonghee; above that village, between it and Pyton, it is seen in several places. The concrete sometimes, but rarely, occurs in the tributary streams.

Mammalian remains in gravels, &c.—In the concrete and gravel mammalian bones are met with, and hence, doubtless, the specimen of *Elephas (Namadicus)* mentioned by Dr. Falconer (Quart. Journ., Geol. Soc., Lond., Vol. XXI, p. 381, November, 1865) was obtained.*

Mr. Wynne found near Moonghee a fragment of some large bone, and, *in situ*, a chipped agate flake, the latter possibly of human origin. I found, *in situ*, a molar of *Bos*, and on the river sand, one or two other teeth probably washed out of the gravel. Bones appeared to be scarce just here, however. Shales frequently occur near the top of the gravel, and perhaps in the base of the clay; they were not observed below, but in this neighbourhood very few sections of the gravel are exposed.

* The history of this specimen is not detailed by Dr. Falconer. The cranium was found by General (at that time Major) Twemlow, then stationed at Aurungabad, who took it to England. This must have been 30 years ago at least. The same officer found mammalian bones in large quantities near Hingolee.

Many of the agates in the gravel have a peculiar dark semitransparent look, resembling flint. Such do not elsewhere prevail amongst the varieties occurring in the traps.

Large numbers of the agates in the gravels are fractured.

In the drift wood, twigs, grass and rubbish deposited at the edge of the river, I found the following land and fresh-water shells. The list may be useful, if the sub-recent and pleiocene deposits be hereafter searched for comparison.

Helix Tranquebarica, Fabr. (the Deccan variety, which is near the shell figured by Reeve in the Conc. Icon. as *H. vitellina*, Pffr.).
„ *atomus*, Fairbank, M.S. (a very minute species of the *Macrochlamys* type resembling *H. vitrinoides* or one of the European *Zonites* in form).
„ *crassicostata*, Benson. *H. fallaciosa*, Fér.
Bulimus pullus,* Gray, 2 or 3 varieties. *B. cœnopictus*,* Hutton. *B. Abyssinicus*, Rüpp. (a finely costulated var. *B. moussonianus ?*).
Pupa (or Carychium ?), sp.
Achatina Vadalica, Benson. *A. brevis*, Pffr. *A. balanus*,* Bens.
Planorbis compressus, Bens. : *P. sp.*,* small : *P. coromandelianus*, Fabr.
Melania tuberculata,* Lam.
Bythinia pulchella ? Bens. *B. sp.* (minute).
Paludina melanostoma.
Unio cœruleus ? Lea, rare : *U. favidens** ? Bens.
*Corbicula arata** ? Bens. : *Pisidium* sp.
Those marked thus* are most abundant.

The road from Moonghee to Jalna traverses for some distance the gently undulating plain, which does not end to the north abruptly in general, though at Chandalla and Bambeera a little escarpment is seen, formed by a hard bed of trap. It is apparently perfectly horizontal. The same horizontality is seen in the range of hills near Umbud and on the traps around Jalna. If there be any dip it must be a very low one indeed, to south or south-east.†

From Jalna to Loonar the traps appear horizontal. No change whatever takes place in them near Loonar. The beds on the edge of the singular crateriform hollow are the usual basalts and amygdaloids abounding in kernels of agate, carbonate of lime, zeolites, &c., coated with green earth as usual. *No dykes whatever were observed.* Ash certainly is met with, but it is the ordinary vesicular ash of the traps, full of zeolite, and such as may be found everywhere in the Deccan. The hollow is as nearly as possible circular, rather more than a mile in diameter. The sides nearly precipitous. A stream from a small spring which supplies Loonar with water has cut a shallow ravine down to the lake which occupies the depression. There is no outlet. The sides of the crater to the north and north-east are absolutely level with the surrounding country, while to the west, south-west, south and south-east, there is a raised rim never exceeding 100 feet in height, and frequently only 40 or 50 feet. In this low raised rim there is no trace of distinct ash-beds or lava flows; it is unquestionably composed of huge blocks of trap, precisely similar to those of the beds below irregularly piled together. The types of the ordinary Deccan traps are so peculiar that their identification is easy. The mass of materials forming the rim resembles those thrown out of an artificial hole in everything except the size of some of the fragments.

The trap beds dip away from the edge of the hollow generally, but irregularly, and appear to owe their dip entirely to disturbance.

There is thus a total absence of everything which in general characterizes a volcano. And yet without volcanic action it is inconceivable that such a hollow should have been formed. No process of aqueous denudation can explain it. The rim, too, appears formed from the fragments ejected from the crater. True, this rim cannot contain one thousandth part of the material removed, but the majority was probably reduced to fine powder by repeated ejections, scattered over the country, and removed by subsequent denudation.

† In Sheet 55 of the Indian Atlas, so far as it was traversed, the mapping appeared good, but the shading of the hills is greatly exaggerated. No one would imagine by looking at it that the great scarp represented as stretching away to the south of east from Loonar is only in reality about 100 feet high in general, and never, so far as I saw, much over 150 feet, if it is anywhere so much. Moreover, it rises gently and not abruptly. The country in general is comparatively level, low flat topped rises, and broad undulating plains, less cultivated than is the case to the westward. No hills of any height occur.

The hollow might be due to sinking, but in this case it is probable that the trap beds around the rim would dip towards the hollow rather than away from it, while the rim is simply unaccountable on such an hypothesis. It is certainly strange to find so well marked a crater without any trace of anything ejected from it. Such a crater might just as well have been found in sedimentary rocks.

Malcolmson's description (Trans. Geol. Soc., London, 2nd Ser., Vol. V, p. 562), is admirable in every way; he observes well that if denudation had removed any cone formed of scoriæ and lava, the crater itself could not have preserved its form uninjured.

Dr. Carter's description, (Journal Bombay Br. Royal Asiat. Soc., Vol. V, p. 324), copied from a manuscript by Dr. Bradley, is very incorrect. The latter found lava flows, or, as he terms them, lavic currents proceeding from the crater, greenstone dykes and scoriæ. I did not discover the two former. Scoriæ I certainly found, but they came from brick-kilns.

The water has a peculiar saline taste. It is so heavy that a slight breeze does not appear to ruffle it. It looks like a lake of oil. There is a slightly unpleasant smell caused by the decay of a green scum *(? confervæ)* which occurs on it. Malcolmson's analysis shows that the water contains no lime, yet there is a calcareous deposit on the rocks of the ravine by which water reaches the lake. The accumulation of salt must be due to the absence of an exit. All the salts carried in by streams accumulate, the water evaporates.*

The shore of the lake is of muddy sand. Around is a fringe of babul trees *(Acacia arabica)*, and beyond them tamarind and bhér *(Zizyphus jujuba)* and date palms. The sides are covered with jungle.

By aneroid measurement my camp at Loonar was about 313 feet above the lake. The rim might be in places 100 feet above my camp, so the whole depth can barely exceed 400 feet.

The salt of the lake is largely collected in the hot weather. A Parsee is said to have paid 11,000 Rupees to Government for three years' monopoly. The principal use is for the manufacture of glass bangles for women, for which purpose the salt is smelted with quartz (gár). The purer salt is used by washermen. There are said to be five kinds of salt, but they appear to be merely varieties of the same, differing in purity and state of aggregation.†

East of Loonar Lake the traps appear to be perfectly horizontal. One bed extends for a considerable distance near the villages of Devilgám and Lony, and beyond the last named village to Mudhee, and appears to be absolutely level throughout.

Towards Wakud on the Pain Gunga the beds may dip somewhat to the north; they seem to fall somewhat from Loonar and Lony towards the river, while there is a scarp to the south, but the dip, if it exists, is very low.

The Pain Gunga near Wakud and for many miles below is a deep sluggish stream, with earth banks covered with grass and exposing no section at the sides. Trap occasionally but rarely shows. Near Muslah a little gravel is cut through here and there.

From the Pain Gunga the road leads over an undulating plain, stony in places, to Bassim, and thence to Mungrool. Between Parudee and the latter place the road for five or six miles traverses a very stony plain, covered with trap boulders, the majority small, not above 2 to 4 inches in diameter, and unusually well rounded, not by rolling, but by weathering. The bed of trap from which they are derived (by weathering), and which forms the surface throughout, is compact, and very minutely crystalline, containing no olivine, nor any other mineral distinct from the mass, and, so far as I observed, neither zeolite nor agate nodules.

To the north this bed ends in a low scarp (not a great range, as represented on the map). It may consequently have a slight dip to the south, but if so, the inclination is so small as to be imperceptible.

From Mungrool the road taken‡ leads east through the Woon or south-east district of Berar. A scarp is descended about 4 miles east of Mungrool, and a second about

* This does not alone, however, account for the composition of the solid contents of the water, for which see Malcolmson, l. c.

† Alexander, Ed. Phil. Journ., 1824, Vol. XI, p. 308: Orlebar, Proceedings of Bombay Geogr. Soc. for February, 1839, p. 35: Buist, Ed. New Phil. Jour. 55, Vol. I, New Ser., 260: Newbold, Journal Royal Asiatic Society.

‡ From Mangrool I proceeded nearly due east to Mangali, and thence north to Nagpúr.

12 miles further on. The rocks appear perfectly horizontal, and these scarps which are not of great height may be merely steps in the descent from the high ground, and the upper traps of the Deccan plateau to the lower ground and inferior formations of Nagpúr. At the same time it is quite possible that the traps have a low dip to the west, but if so, it is, as usual, so slight as to be imperceptible.

The country continues to fall beyond Dharvi towards Larkeir. A little south-east of Larkeir the traps have a distinct low dip, about 2° to north or north-east. A similar low northerly dip is seen about the village of Both. There are low scarps to the south, and long slopes on the north side of the hills.

Near Kini, a few miles west of Yeotmahal, there are some small rounded hills of very compact laterite. It is highly ferruginous, and might doubtless be used as iron ore. It is generally concretionary in its structure (but not formed of minute concretions aggregated together like the Bengal laterite), and covered with the usual brown glaze. Some fragments show distinct stratification, and pass into ferruginous shale. The mass of the rock resembles the laterite of Mahableshwar, and like that contains yellow or white clay in small angular or rounded fragments.

East of Yeotmahal other knolls of laterite occur. They are about 100 to 150 feet high, but it is impossible to see how much consists of laterite and how much of trap. The laterite appears to be horizontal, but only isolated caps remain. It contains small rounded grains apparently of decomposed trap.

Yeotmahal stands high: there is a considerable ascent to it from each side. To the east the road continues to descend towards the Wurda valley and about Kalam emerges from low hills into a broad open plain. The traps along the sides of the hills appear horizontal as usual.

There is some peculiar compact and crystalline limestone near Ralagao and Antargao, apparently intertrappean, but so far as was observed unfossiliferous. Its character differed from all other intertrappean beds seen.

The boundary of the trap at the Wurda on Malcolmson's map (Trans. Geol. Soc., Lond., 2nd Ser., Vol. V) is incorrect. He makes the subjacent formations extend in a great way to the northward and westward. Really all is trap on the Wurda to below its junction with the Wunna.

No intertrappeans (unless the limestone of Ralagao belongs to that formation) had been met with throughout the Deccan or anywhere along the road until between the Wurda and Mángali. Near the village of Dodchi, 5 or 6 miles east-south-east of Pohna and to the west of the village, there is fine compact brownish-white limestone with fragmentary fossils and occasionally perfect Melanias *(M. quadrilineata ?)*. East of the village a good section of limestone associated with fine white and yellow shales is seen in a stream with trap both above and below. In the underlying trap are fragments of the limestone enclosed. The amount of trap seen below is very small, and limestone may recur beneath, otherwise the former must be intrusive. It does not follow that the intrusion is more than local. The shales contain *Cyprides* in abundance, with fish scales and wings of insects. They dip slightly to the northwards.

In the Wunna close to its confluence with the Wurda a fossil vertebra of some large animal was pulled up. Probably the ossiferous gravel occurs here.

Trap occurs at Chikni; thence to Samli very little rock could be observed. At Dongurgaon, 2 or 3 miles south of Chikni, is a low ridge of hard siliceous rock, but whether it belongs to the gneiss series, or is one of the usual sedimentary rocks more hardened than elsewhere, it is impossible to say.

At Almoodi south of Samli trap occurs, probably an outlier. At Talligaon just north of Almoodi between Samli and Mángali close to a tank sandstones fine, hard and compact in general, containing bands of pebbles and conglomerates in places, occur with a north or north-east dip (towards Mángali). The sandstones are white and grey, with specks and patches of bright red. The pebbles in the conglomerate comprise vein quartz, quartzite, metamorphics of various kinds, red jasper (rarely) and a somewhat sandy rock having the appearance of silicified wood or coral. Beneath the conglomeratic beds are some fine red argillaceous sandstones.

Agate Knife found near Pyton, Upper Godavery.

From north of Samli to 200 or 300 yards north of the deserted village of Mángali all is trap. About Samli no rock is seen, nor are any sections seen south of the trap between Talligaon and Mángali. Coming south from the trap at the latter place the first sedimentary rocks seen are fine grey quartzose sandstone, conglomeratic in places, as compact as Vindhyan sandstone, much more so than Damudas usually are,* having a general resemblance to the beds at Talligaon.

Just south of these are the old quarries whence Mr. Hislop is said by the villagers to have obtained his fossils. The rock is a very fine deep red argillaceous sandstone, shaley in parts. Thin layers of a yellow colour are frequent, and these appear to be richer in fossils than the red portions. *Æstherias* (of two species apparently) abound, and some ill marked plant-remains also occur.

The surfaces of the slabs are frequently covered with irregular pits, and appear as if corroded by surface waters. This is curious, as argillaceous sandstone is not a rock easily dissolved by water, yet it seems difficult to account for the corrosion otherwise.

From Mángali to Hingunghat and thence to Nagpúr no rock except trap is seen. The country is mainly an open cultivated plain, thickly covered with cotton soil, a few scattered flat-topped hills occurring towards the south, and nearer to Nagpúr some well marked hill masses come in to the westward. The traps wherever seen are apparently perfectly horizontal.

On the road from Nagpúr to the Wurda on the way to Oomrawatee all is trap, perfectly horizontal to all appearance, except an inlier of *Damudas* near Bazargaon, (not examined), and some isolated caps of laterite near Koondallee.

July 1866.

On the AGATE-FLAKE found by MR. WYNNE, in the Pleiocene(?) deposits of the UPPER GODAVERY, by T. OLDHAM, ESQ., LL. D., &c., &c.

On the accompanying Plate (Plate 1) I have given full-sized figures of the agate-flake referred to above (p. 61) by Mr. Blanford—Mr. Blanford here says, 'possibly of human origin.' Further examination and comparison satisfied him of the true nature of this specimen. He said (Proceedings Asiatic Society, Bengal, October 1866), "I was at first very sceptical as to the genuineness of this flake, but a recent examination and comparison of it with some of the Jubbulpoor specimens have strongly inclined me to believe that it is really of human manufacture:" and he pointed out the similarity with one of those found near Jubbulpoor.

The flake here represented was found by Mr. A. B. Wynne while searching the banks of the Upper Godavery for fossil bones. It was discovered just below the village of Moongee, near Pyton. The river cliff here has a height of about 50 feet. And in a bed of uncompacted sub-calcareous conglomerate or concrete, gravelly and containing shells of species similar to those now living in the neighbourhood, the specimen was found imbedded. A brief but careful search was made in the neighbourhood for other specimens, but without success. Not more than 15 to 20 miles, however, of the river could at the time be visited.

The flake was found about 20 feet above the base of the cliff. Its general form and character will be understood from the Plate better than from a description. It is formed from a compact light coloured agate chip, which near the surface has become blackened, and in two parts the original smooth ferruginous (rolled?) surface of the agate mass remains. The flake is rudely triangular in section, one side being flat, while between the two edges, although not centrally, it rises on the other side into a ridge. The whole is slightly curved, and at one end the sharp edges are curved so as to form a slight reflexion of the whole flake, giving that end very much the form of the curved end of a carving knife for game. The other end of the flake has a lateral extension which may have served as a means of attachment to a handle. The sharp cutting edges are much blunted and hacked, obviously by use. The total length of the flake is $2\frac{1}{2}$ inches; its breadth, which is tolerably constant for its entire length, is $\frac{7}{12}$ inch.

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* This appears to be universally the case near Nagpúr. The Damudas and Mángali beds are much harder and more compact than the corresponding rocks in Bengal and the Nerbudda valley. However, this remark is based on but a slight acquaintance with the Nagpúr beds.

The first notice of the discovery of this flake was given at the meeting of the Asiatic Society of Bengal on the 6th December 1865. The specimen had not then reached me, but judging from the description I had no doubt about its character, and the matter was brought forward as of "the highest interest." I then said: "Many of the members of the Society are perhaps not aware that, spreading over a large area, in the country drained by the upper waters of the Godavery and its affluents, there is a widely-spread deposit of clays and gravels containing remains of large mammalia, which are probably of the same kind as those which occur in the similar gravels and clays of the Nerbudda valley, and of which the Society possesses many specimens. From these gravels and in the valley of the Godavery near Pyton, an agate flake, bearing evident marks of having been artificially made, has been dug out recently by Mr. Wynne of the Geological Survey. This is a fact of *great importance*, and we must only hope that further research will tend to clear away any difficulties that now remain, and add to the history of these interesting relics of the early inhabitants of these countries," (p. 207). This important discovery of Mr. Wynne's was alluded to by Mr. H. F. Blanford in a letter quoted in the Geological Magazine (London) for February 1866 (where Mr. Wynne's name is erroneously printed Byrne), p. 93. And Mr. Wynne himself gave a more detailed account of the mode of its occurrence in the same Magazine (June 1866, p. 283). Mr. W. T. Blanford more recently (October 1866 and September 1867) has again alluded to this discovery of Mr. Wynne's as bearing on the early appearance of man in India.

This question of the antiquity of man in this country long since excited much interest. Almost the earliest speculations in which my lamented friend Hugh Falconer indulged when the Sewalik fauna was beginning to unfold its richness to him were on this point, and he, to the last, believed that there was good reason to suppose that several of the animals whose remains were found imbedded in the so called miocene deposits of the Sewaliks had been cotemporaries of man. Much more therefore would he have been prepared to admit the validity of proof tending to establish his existence at a more recent period.

Unfortunately as yet we have no specific determination of the animal remains from the Godavery valley excepting in one case *(Elephas Namadicus)*. Bones of oxen, &c., have been found, but have not been identified specifically. Still looking to the marked general resemblance both in mineral character and in mode of occurrence and distribution, and to the fact of the comparative proximity of the Godavery to the Nerbudda, there can, I think, be little doubt that these similar deposits in the two valleys are approximately of the same geological age. From the Nerbudda valley a large number of species and of genera have been determined, and to these deposits Falconer assigned the general age of 'pleiocene' in these cautious words, alluding at the time specially to the researches of the Geological Survey of India: "In designating the formation as pliocene which I have during many years, I have been guided by the indications of the mammalian fauna, as intermediate between the miocene of the Irrawaddi, Perim Island and the Sewalik Hills, and that of the existing period" (Quarterly Journal, Geological Society, London, XXI, p. 383). In the same masterly paper, Dr. Falconer pointed out that no trustworthy cases of the occurrence of very ancient human bones, or industrial objects, have yet been established from the section of the Jumna and Ganges, but that they may be looked for on a more careful and extended search, stating also that the ancient fossil Mammalia of the Gangetic valley belong to the pliocene fauna of the Nerbudda, "to which also it would appear certain that the deposit of the Godavery" (from which the flake now described was obtained) "also belong."

The vastly interesting results which these researches involve have for years past been most closely and keenly discussed in Europe and America. The antiquity of man is there one of the most eagerly investigated questions of modern science, while in this country, where so many reasons combine to indicate a greater probability of success, but little has been done. It will be useful to quote here the eloquent words of Dr. H. Falconer on this subject. After referring to the curious support which the discovery of the huge *Colossochelys* served to give to mythological tradition, and the inference that this animal may have lived down to an early epoch of the human period, he proceeds:

"It is not meant to be urged now, after a lapse of more than 20 years, that any serious claim can be preferred on the speculation put forward in the passages above cited. But it will perhaps be admitted that the mind of the observer from whom it emanated was then occupied with the subject of the possibility of the remote antiquity of man in India

on palæontological evidence. It is true that the expressed view is, that the *Colossochelys* may have lived down to an early epoch of the human period, and not that man had lived back to be a contemporary of the tortoise, now proved to have been miocene. But the two views are reciprocal; and the form of expression selected on the occasion was that which was least calculated to provoke ridicule, or to shock the strong prejudices on the subject which were then dominant among educated men.* And so firmly was-not merely the possibility, but the-probability of the case impressed upon our minds, that Captain Cautley and myself were constantly on the look-out for the turning up, in some shape or other, of evidences of man out of the strata of the Sewalik Hills, partly from considerations of a different order, to which I shall briefly allude.

"The cataclysmic speculations of Cuvier and the diluvial theory of Buckland were then exploded. The wide spread of the plains of India showed no signs of the unstratified superficial gravels, sands, and clays, which for a long time were confidently adduced as evidence that a great diluvial wave had suddenly passed over Europe and other continents, overwhelming terrestrial life, and leaving the marks of its course and violent action in those enormous deposits of transported debris. Every section along the Gangetic plain indicated that the superficial strata there were of local origin, and the result of tranquil sedimentary deposition. Viewed in the light of a strictly physical inquiry, the chief rational argument in support of the opinion that the advent of man upon the earth dates from a very modern epoch was first, the negative evidence in the non-occurrence of human relics, and next the fact that taking him in conjunction with the mammals with whom he is now associated, they appeared, as a group, to belong to a new order of things strikingly different from that of the immediately preceding period. The mammoths, wool-clad rhinoceros, the cave-lions, and spelæan hyænas, the Irish elk, &c., of the European fauna were all extinct, although the carcasses of some of them had been discovered, under favorable circumstances, in the most perfect state of preservation. Facts of corresponding import were yielded by a glance cast upon the latest palæontology of the American Continent. There also the huge extinct edentata, the mammoth, and the mastodon indicated a different order of life, especially from that now existing. But in India the problem presented itself under another aspect. There no break was visible in the tranquil succession of deposits, no interference of a general oceanic submergence, followed by incoherent beds of sand and gravel, no intercalation of glacial phenomena to disturb the previous system. The present physical order of things -modified only by alterations of level, by upheavement and depressions—could be traced back, in an unbroken chain, to the ossiferous strata of the valley of the Nerbudda and of the Sewalik Hills. Results in harmony with these indications were yielded by a retrospect cast upon the system of organized life. The *Mastodons*, the *Stegodons*, and the *Loxodon* Elephants were extinct, as were also the *Sivatherium*, the *Chalicotherium*, the three-toed *Hipparion-Horse*, the *Hexaprotodon*, the *Merycopotamus*, and other peculiar forms. But they were found associated in the same Sewalik deposits with species of true *Equus*, of *Camel* and of *Giraffe*, the two last being characteristic cotemporaries of man at the present time. The pliocene fauna of the Nerbudda valley produced, along with the miocene *Stegodon insignis* of the Sewalik Hills, an extinct Elephant *(E. Namadicus)*, the dental system of which is closely allied to that of the existing Indian species; a true *Hippopotamus*, and, not to mention others, a true Taurine Ox, *Bos Namadicus*, and a huge Buffalo, *B. (Bubalus) (Palæindicus)*, which is nearly approached by the living 'Arnee' of the forests of Assam, being the stock from which the domestic Buffalo of Oriental countries is supposed to have sprung. That the actual order of the present system of life had begun during the Sewalik period was indicated by the living Gharial Crocodile and *Emys tecta* being found associated with the extinct mammalian forms. And of the latter, some, like *Stegodon insignis*, accompanied by a species of *Hexaprotodon*, descended to the pliocene period of the Nerbudda fauna, to be associated with a true Taurine Ox and with a Buffalo which hardly appears to differ more from the living *Arnee* than does the ancient *Bison priscus* from the living Aurochs. Another fact chimed in with special force. Among the four or five species of Sewalik Quadrumana alluded to above, one was inferred by Sir Proby Cautley and myself, in 1837, to have been a large Ape, exceeding the size of the Orang-Outang, but of unknown

* M. M. Garrigou and Filhol recently (April 20th, 1868), requested the opening of a sealed packet, which they had deposited with the Academy of sciences, Paris, so long since as 1861. In this they had shewn the probability of man's existence in the miocene age, from observations made in the deposits of Sansan. The evidence consists of bones split longitudinally, &c.

immediate affinity. This opinion was founded upon a canine tooth of an old animal, which is figured and described in the Journal of the Asiatic Society of Bengal (Vol. VI, p. 359). Five years afterwards, in 1842, I instituted a close comparison between the fossil specimen and the corresponding tooth of three skulls of the Orang-Outang, contained in the Museum of the Asiatic Society in Calcutta, and found that their agreement was so close that I conjectured that the extinct Sewalik form had been a large Ape allied to ***Pithecus satyrus***.

"A quadrumanous astragalus derived from the same strata approached in form and proportions so near to that of the existing Honuman Monkey, *Semnopithecus entellus* that the help of the callipers had to be put in requisition to enable us, in 1836, to discriminate them by differences not exceeding millimétres. The distinction between the fossil and the recent bone is hardly greater than that which might be expected to occur in any two individuals of the living species. Here, then, was clear evidence, physical and organic, that the present order of things had set in from a very remote period in India. Every condition was suited to the requirements of man. The lower animals which approach him nearest in physical structure were already numerous. The wild stocks from which he trains races to bear his yoke in domesticity were established. Why then, in the light of a natural enquiry, might not the human race have made its appearance at that time in the same region? Cuvier, notwithstanding his strong bias in favor of the modern appearance of the human race, admitted, in language which has often been overlooked in later discussions, that man may have lived before the last great revolutions which were the subject of his disquisition: 'Tout porte donc à croire que l'espèce humaine n'existait point dans les pays où se découvrent les os fossiles, à l'epoque des rèvolutions qui ont enfoui ces os; car il n'y aurait eu aucune raison pourqu'elle èchappàt toute entière à des catastrophes aussi générales, et pour que ses restes ne se retrouvassent pas aujourd'hui comme ceux des autres animaux; mais je n'en veux pas conclure que l'homme n'existait du tout avant cette époque. Il pouvait habiter quelques contrées peu etendues, d'où il a repeuplè la terre après ces évènements terribles,' &c. The valley of the Ganges seemed to present the exceptional conditions here demanded; it was exempt from the protracted submergence under the ocean, the effects of which on Europe suggested the idea of cataclysmic revolutions. I dwell upon the subject now in the hope that, when the palæontological exploration of the Sewalik Hills and Nerbudda valley, or of other equivalent formations, is resumed, these remarks may attract attention in India, and that a keen look-out may be kept up for remains of the large fossil Ape above alluded to, and for traces of man, in some form of equally remote antiquity. For it is not under the hard conditions of the glacial period in Europe that the earliest relics of the human race upon the globe are to be sought. Like the Esquimaux, the Tchuktshes, and the Samoyedes on the shores of the Icy Sea at the present day, man must have been then and there an emigrant, placed under circumstances of vigorous and uncertain existence, unfavorable to the struggle of life and to the maintenance and spread of the species. It is rather in the great alluvial valleys of tropical or sub-tropical rivers like the Ganges, the Irrawaddi, and the Nile where we may expect to detect the vestiges of his earliest abode. It is there where the necessaries of life are produced by nature in the greatest variety and profusion, and obtained with the smallest effort; there where climate exacts the least protection against the vicissitudes of the weather; and there where the lower animals which approach nearest to man now exist, and where their fossil remains turn up in the greatest variety and abundance. The earliest date to which man has as yet been traced back in Europe is probably but as yesterday, in comparison with the epoch at which he made his appearance in more favored regions." (a)

Years since the officers of the Geological Survey engaged in Madras discovered chipped stone-implements identical in character and form with those so generally known from the Amiens and Sussex Gravels. These have been described by Messrs. Foote, King, Oldham, &c., but unfortunately there was nothing tending to determine exactly their age. They occurred abundantly in a lateritic conglomerate, or somewhat compacted gravel, near to, or on the surface; others, again, more nearly approaching in character the flake now described had been discovered in the vicinity of Jubbulpoor. These latter, as is this Moongee specimen, exactly represent the flakes so frequently found associated with human remains in Europe, under

(a). H. Falconer, Palæontological Memoirs and Notes, Vol. II, p. 576, and Quar. Jour. Geol. Soc., London Vol. XXI, 1865, p. 386.

circumstances indicating great antiquity. Unfortunately, however, very little information was obtained regarding the mode of occurrence or the antiquity of these specimens. And it therefore was of the highest interest to find absolutely in the bone-bearing beds of the Godavery some 30 feet below the surface at that place, and in a bed, not of soft easily movable silt or sand, but of hard compacted calcareous conglomerate, the flake of which drawings are now given.

It is, however, as yet the only case on record of such occurrence of works of human art *in these beds* in this country. And we would earnestly seek the co-operation of those who may be more permanently in the vicinity of these deposits to institute and maintain a search for others. Mere casual visitors have comparatively but slight chance of success in such researches.

September, 1868.

The boundary of the VINDHYAN SERIES in RAJPOOTANA, by H. B. MEDLICOTT, F. G. S., &c., &c.

The strata of the Vindhyan period have long since received a prominent place in the rock series of Hindustan. In the typical area between the Nerbudda and the Jumna, the Geological Survey had been for some time more or less accurately acquainted with the relation of the Vindhyans to the underlying rocks along the south-eastern and north-eastern boundary, when, in the cold season of 1865-66, I was sent to investigate their western extension towards the Arawali range in Rajpootana. The formation as a whole shows no effects of disturbance *ab extra*. Along the entire north-eastern boundary, wherever older rocks are exposed, the Vindhyans rest totally unconformably upon all, whether crystalline schists or unmetamorphic strata. The junction is normal and undisturbed, being simply exposed by denudation; and its position coincides more or less with an original limitation of the basin of deposition. Along the south-eastern boundary there is the same total unconformability with all underlying rocks; but here there is a margin of variable width in which the strata are more or less intensely disturbed; for the most part this has the character of simple elevation outside the boundary or of depression inside it; but the junction is often locally faulted. Here too, however, there are indications of an original limitation of the deposits corresponding with the actual boundary; several of the sub-groups thin out and disappear on approaching it. Besides the feature that has been noticed in the north and south extension of the Vindhyan groups there is an analogous feature in the east and west distribution; along the south boundary several of the groups are overlapped and so disappear from east to west; thus it is only in the eastern portion of the area that we find the important and peculiar strata which are known among us as the lower Vindhyans, and which are well exposed throughout the entire length of the Sone valley.

The examination of the third and western boundary of this area has not added anything to our general knowledge of the Vindhyan rocks. The boundary is as sharply defined as elsewhere; the groups that are seen are like their representatives 500 miles to eastwards, with which they are continuous; and even the features of the boundary are like what is seen in the Nerbudda valley. The lower Vindhyans do not appear anywhere along this junction; but the several groups of the upper Vindhyans—the Bundairs, the Rewahs and the Kymores—are well represented. The famous old fort of Chittorgurh stands close to the western boundary, upon a scarped hill of Bundair sandstone, an outlier of a plateau to the east; the limestone and shales of the same group being well exposed in the plains at its base. The same beds are also well seen to the north-east, about Parsoli and at Boondi, close to the boundary; and at several places the lower groups crop out along the boundary from beneath the Bundairs. Although here, as elsewhere throughout this series, there is a strong apparent likelihood for the deposition and preservation of fossil remains, none have been discovered.

To the west of Bagh the steep scarp of the Deccan trap bounding the Nerbudda valley on the north is rather the face of a ridge than of a plateau. There is a very considerable fall on the northern side, and the country is deeply undulating instead of formed of open plains as at a few miles distance to the east. In the valleys and low ground about Jubbooah the crystalline rocks are freely exposed. We here, in fact, come upon the western boundary of the Malwa plateau. It is a very irregular orographical feature, being purely determined

by denudation, and it is interesting to observe its very apparent relation to the distribution of the rocks. The river Mhye with its tributaries is the first of the streams flowing northward from the south edge of the plateau which has not to encounter the resistance of the horizontal Vindhyan strata; beneath the trap it only encounters the decomposable and variable rocks of the metamorphic series, and erosion has gone on unchecked. After a northernly course of many miles the Mhye bends westwards and southward into the gulph of Cambay.

The greater part of the plateau of Malwa is formed entirely by the great Deccan trap formation. In going northward along the table land from Indore through Rutlam, the Vindhyans first appear at Mundesor, about 140 miles from the Nerbudda; they gradually emerge from beneath the great expanse of trap to the east. In following a parallel course a little to the west, along the boundary of the table land, it is seen that the non-appearance of the Vindhyans to the south is not owing to their being concealed by the trap; for all along the boundary the crystalline rocks immediately underlie the volcanic rock; and an examination of the Vindhyans themselves shows that their boundary at Mundesor is a feature of very ancient date. It runs in a north-west by west line from Mundesor, and the Vindhyans rise into small plateaus in that direction, the strata being quite horizontal. Even on the high level signs of disturbance are traceable along the line of contact, but it is where the strata run out along this strike into the low ground that the structure is fully seen. Here the lower groups of the upper Vindhyans crop out with a rapidly increasing north-easterly underlie against the crystalline rocks; the lowest band being a conglomeritic sandstone. In the opposite direction the boundary at Mundesor strikes towards Hoshungabad and Burwai, the lowest point to which the Vindhyans reach in the Nerbudda valley.

About the point where the Mundesor line of boundary strikes the edge of the plateau, the boundary makes a sudden bend of half a right angle, running due north for 40 miles, passing about 20 miles west of Neemuch. This is the most westernly position of the Vindhyan boundary. With it there commences an immediate change in the character of the contact: the margin of disturbed rocks is several miles wide, marked by flat, symmetrical, anticlinal flexures, causing ridges along the outcrop of the sandstones with intervening valleys on the contorted shales.

These features are well seen where the Neemuch and Oodipoor road crosses. The actual line of junction is marked by no special feature, the contact taking place on the low ground with the Vindhyan shales, which seem to be about equally liable to erosion as the gneissose series. It seemed to me that the shales at the contact were those with which the limestone is associated and which I have considered to be of the Bundair group. There would thus be presumption in favor of a fault.

Close to Chittorgurh there is another abrupt bend in the direction of the boundary; from north and south it turns to the north-east. For some distance at least, in this new direction, the character of the junction is the same as that last described; the Nusserabad road north of Chittor crosses at the same level from the crushed Vindhyan shales, with limestone, on to the friable granitic rocks. The strike of the contortions in the shales has already become identical with the new direction of the boundary. The actual contact often runs in a slight depression of the surface, there being no vein-stone visible or any direct evidence for the supposed fault. Where I next examined this boundary near Parsoli, some 15 miles north-east of Chittor, although its strike and that of the strata continue steadily to north-east, the conditions of the junction have entirely changed, having again assumed the form noticed in the Mundesor reach. From the north-west one approaches upon granitic and schistose rocks up to the very base of a steep ridge of sandstone in which the dip is south-easterly. Beyond this ridge there is a steady longitudinal valley upon crushed shales, without limestone; then again another ridge of sandstone with the same south-easterly dip; just inside this ridge the village of Parsoli stands in an irregular open valley formed of the shales and limestones, the plateau-hills to the south-east being formed of the sandstone overlying the same. This is the most compact section I observed of the three groups of the upper Vindhyans.

At about 4 miles to north-east of Parsoli the regularity of the section terminates in the most obscure manner, involving a fresh change in the direction of the boundary and in the strike of the rocks. At Bumunia and Singoli the sandstone ridges come to a sudden termination along an east-west line, facing a low wide-spreading plain. The feature is

manifestly connected immediately with structural conditions of the rocks. At the end of the outermost ridge, that of the Kymore sandstone, I could trace a change in the dip from the steady south-east of the ridge to east-north-east, to north-east, and to north-north-east, there being here a little spur of sandstone tailing off to the west-north-west. Of the middle ridge of Rewah sandstone I could make nothing; at its present termination the south-east dip is still maintained. On the undulating high ground formed by the top band of sandstone, that of the Bundair group, the undulations which at Parsoli corresponded with the north-east strike, are rapidly replaced towards Singoli by a north-west strike, and the outermost ridges underlie towards the plains to the north. On the low ground for some distance in front of all the ridges, Vindhyan shales (I cannot say of what group) are the only beds seen; they are much crushed, but with a prevailing east-westerly strike. On a mere cursory survey and without any map of the ground my study of the sections could not be sufficiently detailed to offer any explanation of these complex stratigraphical features.

From Singoli the tracing of the exact line of junction is greatly obscured by a change in the nature of the older rocks in contact; instead of the easily distinguished granite, gneiss and schists, the prevailing rock here is an imperfectly cleaved clay-slate, often scarcely distinguishable from the crushed Vindhyan shales. Superficially the change is indicated by the abundant debris of quartz derived from the veins that freely traverse the slates, but are altogether wanting in the Vindhyan rocks. The run of the boundary here would seem to be much less regular than what we have seen to the south. Towards Boondi the junction is again somewhat better defined, at least locally. Boondi stands at the end of a valley formed on an anticlinal of the Bundair group (taking the limestone associated with the shales as a criterion of that group). The strike is about 15° north of east. On the north side of the valley is a massive ridge of quartzite sandstone, which must, at least in part, be formed of the Bundair rock. The slates are found close to the north base of the ridge. The difficulty of discriminating the series is increased in this vicinity by the occurrence of a limestone, not markedly different from that of the Vindhyans, among what I took to be the slates.

The crystalline metamorphic rocks underlying the Malwa trap on the west show much variety, and invite a closer examination than I could give. They are decidedly gneissose; and granitoid masses are frequent. There is one strong and persistent run of a coarse conglomerate. It is well exposed in the river at Tandla: the matrix, though coarsely foliated, is rather earthy, the pebbles are often large and subangular, not always elongated in the strike: whatever they may once have been they are now mostly granitoid. North of Tambèsera the same is well seen: the boulders in it are sometimes 2 and 4 feet in diameter; they are thinly and partially distributed in the matrix. There is a crystalline limestone largely developed alongside the conglomerate. I also noticed some earthy graphitic schists associated with it. At Talwara, 10 miles to west of Banswarra, a white granular limestone is quarried to some extent. A north-westerly strike prevails throughout these rocks.

Rocks of semi-metamorphic character were first observed north of Chittorgurh. Ribs of quartzite tail out from a considerable group of hills to the north to within half a mile of the Vindhyan boundary. They are associated with earthy ferruginous flaky slates or semi schists. They are in very irregular junction with a coarse, quartzose, friable granitoid rock, which largely prevails here in the metamorphic series; it is quite massive and amorphous. It is found in contact with the quartzite, and within a few yards is separated from it by many feet of the slates; yet I noticed no case of special intrusion or any signs of contact metamorphism. At Gungrar the quartzites have become very massive, apparently overlying the slates, and forming considerable hills. A limestone shows very subordinately in these slates. I was greatly struck here by the resemblance of the lithological and stratigraphical conditions to those of the slates and quartzites of the Rajgir hills in Behar. The plains south of Hameergurh are formed on these slates, the northernly strike having changed to a steady east-north-east direction; and thus they stretch away to the east, being the same as have been already noticed in contact with the Vindhyans from Singoli northwards.

Of rocks younger than the Vindhyans the Deccan trap is almost the only representative within the area I refer to. At one spot about a mile south of Jabbooah, near the north base of the great ridge of trap, there is a small remnant of the Bagh cretaceous deposits;

sandstone and bryozoan limestone, scarcely more than 10 feet in all, capping a low ridge of crystalline rocks for about a mile in length, and then itself covered by the trap. Although I examined the base of the trap at many places in the vicinity and all along for nearly a hundred miles to the north I found no other representative of the Bagh beds.

Of the trap itself a great variety occurs within the area I traversed. I did not notice a single instance of intrusive trap of this age. The trap is first met with on the Great Deccan road, at about half way between Sipri and Goonah; and from here its spread is unbroken, save by a few projecting ridges and points of the Vindhyan sandstones, and this only in the northern part of the area. Near Kotra I noticed large blocks of baked sandstone weathered out of a trap flow. I nowhere found large siliceous geodes so abundant as in the bottom flows at the boundary of the trap area. On the whole, porous vesicular trap highly charged with zeolitic matter largely predominates. In the road cuttings through the hills south of Goonah there are excellent sections exhibiting the distinct flows of rock. In several I noticed the gradual passage, within 8 or 10 feet, from a close-grained crystalline ball trap to a highly vesicular and earthy rock at the surface of the bed. At the base of a flow also, compact rock takes the place of the large spheroidal trap of the centre of the mass. In the region from Beora to Mehidpur a strong, dark, columnar basalt is constantly met with in the beds of the large rivers. In the western region north of Rutlam a porphyritic basalt is common. It is the hornstone-porphyry of Dangerfield's description.

Intertrappean beds were noticed at many places in the north-eastern part of the area; but always very local, thin and highly altered into a confused agglomeration of crystalline limestone, arragonite and silica. At the village of Bugleri, 3 miles north-west of Mundesor, I noticed at the base of a small scarp of Vindhyan sandstone a bed of breccia made up of Vindhyan debris. Although the fragments were not water-worn the bed seemed to me to be certainly water-laid; and it is overlaid by trap.

Laterite of various descriptions occurs at many places. The regular, primary form of this rock,-that so generally associated with the Great Deccan trap formation,-is found capping the hills south of Goonah; and, again, the plateau on which Augur stands is covered by about 50 feet of laterite, rocky and massive at top, and soft, earthy and ochreous at base, as is generally the case with this deposit.

Black cotton soil occurs frequently over large areas, but its connection with the trap seems very indirect. I frequently observed trap decomposing into an ordinary yellow kunkury clay, this being overlaid, with a sharp surface of junction, by a thick layer of black soil.

August, 1866.

METEORITES.—The Museum of the Geological Survey of India has been enriched, during the past quarter, by a magnificent specimen of the meteorite which fell at Menow, in Mechlenburg Strelitz, on the 7th of October, 1861 (?1862), and also by a perfect cast of the whole mass. This mass was purchased at the time by Baron Reichenbach, and has ever since remained almost intact in his collection. He would not have it cut, and specimens, therefore, excepting a few of very minute size, were unknown in other collections. More recently, Baron Reichenbach has been desirous of disposing of this splendid meteorite, and after sometime it passed into the hands of Mr. Wm. Nevill, now of Godalming, Surrey, whose valuable collection of meteorites is well known. This collection is now, I believe, the finest private collection in the world, and it would rank very high even among the series in Public or Government Institutions. To Mr. Nevill, I am indebted for the splendid specimen now here. It consists of about one-third of the whole mass, showing on all but the cut and polished plane the original crusted surface of the mass. This vitrified crust is coarser, more granular, and altogether less truly vitreous than usual. I have as yet only had the opportunity of seeing the polished surface of the cut stone, and it is not easy to distinguish the structure in this way. The sp. grav. is more than 4, showing the amount of metallic matter in the stone. But a more careful examination of it will be made.

To Mr. Nevill, I am also indebted for the extremely rare specimen of the stone which fell at Perth, Scotland, on the 17th May, 1830. Of this fall, only one specimen was known. This which belonged to Mr. Nevill (having been a part of the Lettsom collection purchased by him) was divided with the British Museum, and the fall was, therefore, only represented

in the collections of Mr. Nevill and of the British Museum. Mr. Nevill has now, with singular liberality, presented his almost unique specimen to the Geological Survey collection. The specimen is small, only weighing 6·5 grains.

In the previous number (p. 39), when noticing the addition of the specimen from **Pultusk**, I had only received the early intimation of the fall, when it was supposed that not more than three or four pieces had fallen. Subsequent research has shown that the number of separate stones, the majority of them being perfectly crusted on all sides, exceeded even a thousand ! ! A perfect shower of meteorites !

DONATIONS TO MUSEUM, &c.

A series of bones of various parts of the Solitaire *(Pezophaps solitaria,* Gmel.) from Rodriguez Island, by Edward Newton, Esq., Auditor General, Mauritius, through Geoff. Nevill, Esq.

Specimen of Meteorite which fell at Perth, Scotland, on the 17th of May 1830, by Wm. Nevill, Esq., Godalming.

Two specimens of roofing slates from Chamba quarries, by Captain J. P. Turton, 4th Goorkas.

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OF

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MDCCCLXX.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1869. [February.

THE VALLEY OF THE POORNA RIVER, WEST BERAR; *by* A. B. WYNNE, ESQ., F. G. S., &c.

The Poorna valley between longitudes 76° and 78° east, is traversed by the 21st parallel of north latitude. It is about 124 miles in length from its upper or eastern end to where it passes into the larger valley of the Taptee; the main directions of both diverging at first so as to include an angle of about 50,° but afterwards becoming more nearly parallel or east and west. The width of the valley may be roughly estimated at from 30 to 40 miles on an average, but is in places greater.

Its boundaries are—on the south, the range of the Adjunta ghâts,—an abrupt scarp of the Deccan plateau produced, and gradually becoming less marked, to the eastward—some hilly and undulating ground forming the watershed in that direction between the Poorna and Wurdah valleys; and on the north, the lofty bold and varied escarpments of the Gawilghur range, which carry a high crest westwards near to where the Poorna river runs into the Taptee, the termination of the mountain range here sinking with some rapidity, though not being by any means abrupt.

The southern ranges pass imperceptibly into the usual steppe character of the Deccan, while the mountains on the north are a complex mass or group with a generally east and west extension, and such summit elevations as 3,595, 3,778, and 3,975 feet, declining gradually northward into the valley of the (upper) Taptee.*

These Gawilghur mountains are intersected by steep glens and wider valleys, sometimes presenting nearly vertical precipices of great but unmeasured height which may in places reach 1,000 to 1,200 feet. The glens and ravines wind intricately among the mountains, affording some very fine scenery, and as their streams seldom retain water for any considerable time, the wildness of this is increased by solitude.

The valley of the Poorna possesses but little variety of geological interest and is principally distinguished by monotonous repetitions of features observable in crossing the Deccan from the seaward to this locality, where each hill and ghât and undulating slope or plain exhibits similar kinds of nearly horizontal flows of gray amygdaloidal trap, with here and there a bed of harder texture of columnar structure, or of bright red bole, or alternations of these; the traps sometimes containing numerous zeolites.

In the river valleys, and where superficial 'rain-wash' has accumulated, a light brown 'kunkury' alluvium is associated with calcareous sub-recent conglomerate below and black cotton soil above, one being quite as occasional and accidental as the other, the conglomerate or concrete being perhaps the most persistent along the river courses, the brown alluvium or (?) "soda soil"† more universal and the cotton soil occurring, subject only to the rule that it is always uppermost.

Upon descending the escarpment of the Deccan into the valley of the Poorna its alluvial plain is entered, often at no great distance from the ghât, and stretching away as far as can be seen; only clear days permitting some of the nearest mountains upon the opposite side

* These heights are taken from a small photograph copy of a map of Gangra by J. Mulheran, Esq.

† This efflorescing brown alluvium is considered by Mr. Blanford different from the "soda soil" of Madras.

to become visible. Heights not being given upon the best maps obtainable, the elevation of this plain and its boundary ranges could not be ascertained even approximately in the absence of a barometer—which is to be regretted, as the main watershed of India separates the sources of the Poorna from those of the Wurdah, the water of the former being discharged eventually at Surat whilst those of the Wurdah are tributary to the Godaveri, which enters the sea below Rajahmundry on the opposite side of the peninsula.

The alluvium of this great plain, although of very considerable depth and occupying so large an area, is as completely isolated from that of the neighbouring rivers as such a deposit can be said to be. A section crossing the valley from the Adjunta ghâts, by Edulabad across the Poorna river, to the western termination of the Gawilghur range, would show the ordinary trap of the Deccan, forming the high ground at either end, and an undulating country between, which viewed from above or from a distance has a plain-like aspect, but frequently exposes the rocks of which it is formed; consisting of the usual traps, here and there covered only by slight detrital accumulations of the same kinds as those of the Deccan. Except on the very banks of the Poorna no considerable quantity of alluvial matter would be found, and this does not extend far from the river at either side. North and south through Mulkapoor a different section would be obtained. Here a wide space, chiefly on the south side of the Poorna, is occupied by fine brown calcareous alluvium with 'kunkur' and is connected by a narrow neck, at Peeprala, with the great alluvial deposit of this valley which in thickness may exceed 150 feet; and nothing else, save varieties of this, is to be seen in or near the river from Dadulgaon on its south bank eastwards up the stream nearly to the "sungum" or junction of the Phairlee river, which enters the Poorna near Kowsa, if we except two or three small exposures of trap in its bed near Peeprala Pulsoad and about three miles west of Burra Golagaon. The Poorna changes its course from the N. N. E. at the junction of the above-named tributary, and thence takes a westerly direction:—the alluvium on its south side seldom extending beyond an average of ten miles from the river and nearly coinciding along its southern boundary with the Nagpoor extension of the Great Indian Peninsula Railway—while on the north it reaches nearly to the base of the mountains. On the east its rather arbitrary and more or less indefinite boundary closely approaches the watershed east of Ellichpoor and bending southward traverses undulating country eventually reaching the flanks of the hills near Oomrawuttee.*

All round the margin of this alluvial tract is a belt of country that might or might not with propriety be included within it, although the surface deposits there do not conceal the underlying rock, the exposure of which was taken as the chief guide in determining the line of boundary. On the north and east, this tract of country is very stony, though nothing resembling an old beach is seen, and it may be supposed that streams descending from the mountains and hills have frequently travelled across this space, their courses subject to lateral deviation, covering the whole of it with the coarser fragments brought down by floods at a time perhaps when the water of a lake or the sea, occupied the basin of the finer alluvium and arrested the boulder-bearing velocity of these mountain streams.†

In every part of the alluvium calcareous conglomerate or concrete is of common occurrence. It occasionally contains fragments of bone or fossil teeth of ruminants, but although sought for, no large accumulation nor even a large fragment of these fossils, was observed. Yet enough was seen to show an identity of the conditions under which these deposits and those of the Nerbudda valley were formed. This sub-recent conglomerate‡ is very frequent in the stony tract above mentioned. It was everywhere searched for worked flints but without success, although one flake was found in a quite similar deposit, forming the right bank of the Godaveri at Pyton in the Deccan, at a considerable distance to the south.

Small land shells are not uncommon in the alluvium, some were preserved and transmitted to Calcutta, but in general they were too fragile for removal. They appeared to belong to existing species. Specimens of *Melania tuberculata; Paludina Bengalensis; Bithinia pulchella; Lymnæa—; Planorbis—; Unio (?) favidens: U.—?* have been recognized.

* Pronounced Oom'rowtee.

† At one place in the stream near Dhanapoor the stony margin seemed to unite with the finer alluvium by alternations of coarse and fine strata two feet or so in thickness.

‡ The native name for this 'concrete' is "Kàrruk."

A deposit of varying thickness (within three feet) and but small lateral extent, consisting of fine dazzlingly white sand finely laminated occurs in the alluvial bank of the Poorna at Paruth. It appears to be composed of comminuted or disintegrated crystals of felspars with a small admixture of clay. It did not appear to be formed of or to contain minute organisms, such as foraminifera, and was not elsewhere observed.

Much of this Poorna alluvium produces efflorescences of salts, of soda chiefly, and in many places the wells sunk in it are brackish or salt. Over a wide tract on each side of the Poorna river, north of Akola and thence eastward towards Oomrawuttee, wells are specially sunk for obtaining common salt from highly saturated brine.

Some of these salt wells near Dyhunda in the lands of Gunoree are from 120 to 130 feet in depth or probably more. They are sunk through yellow clay, then redder clay, and below this a coarse sand or fine gravel from which the water issues with great force. They are lined with wicker work in order to preserve the pottery vessels, in which the water is raised by hand, from breakage. The crystals of the salt are small and it is rather dirty, but during the "dhūp kâla" or hot season, it can be obtained whiter. The wells are numerous over the tract north of the river and some also occur to the south.

That the alluvium of the valley is of considerable depth may be perhaps inferred from the absence of numerous exposures of rock, as well as from the depth of nullahs and height of the river cliffs. The conglomerate, as usual, occurs in its lower portions, but was observed in some places west of Patulla at different heights in the sections exposed. Its constant or frequent occurrence beneath the rest of the alluvium would not prove its being contemporaneous in all places, as the trap rocks, upon which these deposits lie, cannot be presumed to have had a surface sufficiently even to have permitted this.

Whether the whole of this alluvium was deposited in a lake, or by the river travelling from side to side of the valley under other conditions than at present obtain, does not appear. A former estuarine state of things may be indicated by the salt-bearing gravels, or a large salt lake, but the even though interrupted surface of the alluvium is against the probability of its having been deposited by the Poorna under present conditions; while want of information as to the relative levels, obscures the possibility of determining whether the rocky country about Edulabad may not have formed a natural *bund* flooding the country occupied by the alluvium; certainly the stream through most of this is sluggish, but it seems to be a rather strong assumption, that no greater fall than the height of the river banks where it enters this rocky tract—perhaps on an average not more than 30 feet—takes place within so great a distance as extends between this and the upper end of the alluvium, about or S. W. of Oomrawuttee.

Good water is scarce in this district, in some places shallow 'jhieries'* alone can be depended upon for a supply, the wells being brackish and even the river gravels furnishing brackish water if pierced to any considerable depth. A succession of dry years seems to have greatly reduced the usual supplies of water, and very many of the villages among the hills to the north are deserted, it is said, because the streams which supplied them formerly do not now furnish sufficient water. Not improbably the diminution in the supply has been caused by the wholesale cutting down of the jungles which covered the country before the period of the English Raj.†

The hills and portion of the valley south of the Poorna river have been stated to consist of trap similar to that of the Deccan; all the usual varieties of amygdaloid, zeolitic, columnar, hard, gray, and softer, ashy-looking traps occur, their stratification being very perceptible, and always nearly horizontal.

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* This name is applied to small excavations in the sandy bed of a river reaching the water which trickles beneath the surface, and thus becomes naturally filtered.

† Want of water is much complained of at Chikulda. There seems to be no reason why the plateau to the east of the bungalows should not afford a sufficient catchment basin for the station. As the trappean strata of the hill dip N. by W. at 5°, if wells were sunk, the north side of the plateau would be the position to choose with most probability of success. Near the bungalows however the plateau, if such it can be called, is very narrow, and affords a much smaller catchment area, yet even here the hill must contain strata which retain water as it issues from the rocky beds of nullahs, and one well immediately beneath the northern edge of the plateau, and at a considerable height upon the mountain side, is stated never to go dry.

About the Gawilghur range on the north there is a constant dip at low angles in that direction, the lower part of the range being chiefly composed of amygdaloid and soft traps; and hard basaltic beds occurring in greatest quantity among the higher parts of the hills, where such bands may be seen to course along the sides of cliffs and mountains for several miles; a capping of the harder trap remaining here and there on top of an isolated peak or hill, while lower elevations around have less angular and more flowing outlines, being formed of the softer varieties of the trap.

Occasionally along the base of this range, the beds have been thrown into wide curves with very gentle inclinations, their axes dipping but slightly to the northward.

Intertrappean beds are said to occur among the Gawilghur hills; they were only detected in one place, and consisted of hard chert enclosing numerous shells: but though near, this is not properly speaking within the Poorna valley.

Perhaps the most interesting geological feature of this country is the occurrence of a great fault, with a down-throw to the south, which may be very considerable, as it shifts the trap downwards for some two or three hundred feet visible, added to an unknown thickness of the trap which is buried by it, so that trap, of what exact horizon cannot be stated, is brought against the underlying Mahadeva or Bâgh (Tanda)* sandstones. This fault crosses the country in an east and west direction, close to the foot of the Gawilghur range north of Ellichpoor, where the abrupt southern scarp of the range shows these sandstones, occupying the interiors of open curves in the trap like those just now mentioned. The difference of inclination between the sandstone and the traps is but slight, so that their unconformity is, as usual, not very strongly apparent, though it nevertheless exists; the line of contact where the overlying traps rest upon the sandstone, is frequently difficult to see when close by it, though from a distance the difference of coloring and the bold projections of the sandstone outcrop mark it well. The sandstones are chiefly soft or coarse white and even-grained rock, which would doubtless make a good building stone. A large mass of these occurs in the lower portion of the group exposed; above them are conglomerates, other sandstones of similar kind, purple and black shales and flagstones, variegated and white flagstones and shales, and then solid gray limestone with silicious or cherty nodules of peculiarly rugged aspect; these limestones in some places becoming so variegated as to form what if polished would doubtless be a handsome marble.

In this group of Mahadeva or Bâgh beds dips to the north of 10° and 15°, with others more nearly horizontal, may be sometimes seen; these becoming less as the sandstones finally disappear beneath the Gawilghur traps to the north of the cantonments of Ellichpoor. In the river at Nurrha, north-east of the latter place, the section is somewhat unusual. The ground here seems to have been intensely faulted, and instead of leaving the trap and passing over the fault on to sandstone at the base of the hills, trap is again found north of the general line of fault; then occur several large dykes of another intrusive trap different from that usually met with, between which are masses of the limestone, sometimes resting upon a conglomerate, and tilted in various directions at angles of 35° and 50.° Beyond this disturbed locality the next rock seen is sandstone, horizontal for some distance but soon overlaid and covered up from view by the unconformable trap.

In the flaggy portion of the Mahadeva or Bâgh group, impressions of large plants have been observed, and in the shales and some of the limestones numerous small univalve shells.

Fossils were known to have occurred north of Ellichpoor, as mentioned by Dr. Bradley. These sandstones were known to the late Rev. Mr. Hislop, but seem to have been erroneously considered inter-trappean. Lithologically they frequently recalled the appearance of the sub-trappean cretaceous rocks of Bâgh-Tanda and Rajpoor along the Hutnee river, &c., in the valley of the Nerbudda, and it was a disappointment not to find the same, or the same quantity of fossiliferous evidence here, the beds in both places being possibly, or probably, of the same age.

Laterite occurs on the new road from Ellichpoor to Oomrawuttee at a place called Bulgaon or Burgow, about six miles from the latter city. It is more properly a lateritic conglomerate of small pebbles cemented together by iron oxides. It lies horizontally, and has

* Bâgh-Tanda is the name generally used by people when speaking of Bâgh at a distance therefrom.

much the appearance of a re-composed rock, in many places quite incoherent, harder at the top and outsides than internally, and the pebbles are all red, bright purple or ferruginous, glazed outside and not recognizable as derived from any of the traps of the country, unless from their resemblance they might be taken to have come from one of the beds of red bole, which are not very uncommon; but then there is no reason why if so derived they should not be intermixed with other trap pebbles. This has all the appearance of a local deposit, does not crop out in some natural excavations near at the same level, and apparently passes away underneath the cotton soil, but being horizontal or nearly so shews for a considerable distance along a sluggish stream which occurs here, occasionally varying in structure so as to become a mottled white and purple rock of some strength.

In one place on the bank of this stream a little cliff shows the incoherent gravel resting upon a soft ferruginous bed, about 9 feet thick, with some lines like those of deposition. Beneath this are 5 or 6 feet of greenish-gray trappean mudstone, very splintery and breaking up into cubical forms so much that it is nearly impossible to obtain a fresh fracture; some harder parts seem calcareous, and have a fracture resembling that of compact limestone. The laterite may be traced for more than a mile in an east and west direction. Near Budja Kaira, on the larger river here, strong vesicular laterite undulates about horizontally, but does not continue down the stream.

Again at Reethpoor lying to the eastward from Oomrawuttee, there is a quantity of laterite in low swelling undulations—with the usual appearance of lateritic ground, a ferruginous more or less smooth surface and occasional hard projecting knobs, but no good sections of the rock.

At Chickulda (the hill station on top of the Gawilghur range frequented by people from Ellichpoor), the plateau upon which it stands and the surrounding summits have a strongly lateritic appearance such as may be seen at Matheran and other summits of the Western Ghâts.

These indications of laterite, occurring as they do in situations where the uppermost beds of the trap series might be supposed to occur, may indicate a similar or nearly the same lateritic horizon, which is known to occur among the uppermost, if not actually on the top of, the Deccan traps along the Western Ghâts. Otherwise they may be referrible to zones of ferruginous strata more specially lateritic than the layers of red boley trap referred to as occurring in this neighbourhood and on the Deccan plateau; but their limited development and isolated character hardly afford sufficient grounds to reason upon with much probability of arriving at trustworthy conclusions.

The cotton soil or black soil of the Poorna valley, although common enough, as is usual in these trappean districts, has no geological peculiarity here requiring attention. To its development, however, and the fertile nature of soils derived from the trap may be traced doubtless the name which this country has obtained as a cotton-producing district.

On the KUDDAPAH and KURNOOL FORMATIONS: *by* W. KING, Junr., B. A.

The rocks forming the greater parts of the Kuddapah and Kurnool districts in the Madras Presidency have been long known through previous explorers under the names of "Diamond Sandstone," "Clay-slate Formation," &c. They extend over such an immense area, and are found to be so complex in their stratigraphy and so diversified in their relations, particularly among the lower and older groups, that their systematic survey is not yet quite completed, though some years have already been spent in their examination. Sufficient, however, is now known of them to warrant the giving a short sketch of this interesting series of rocks.

The series consists of great thicknesses of quartzites (altered sandstones), slates, trap-flows and their associates, and limestones; and these are found to constitute two (if not more) great and distinct formations. To the older, being so typically and largely exhibited in the Kuddapah district,* the name KUDDAPAH FORMATION has been assigned; while the newer KURNOOL FORMATION derives its appellation from the adjoining district over which it is so very well seen.

* Kuddapah town itself is on shales and limestones of one of the groups in the newer formation.

The area of these rocks, from the Kistnah river down to Naggery Nose,* their southernmost extremity, is about 13,500 square miles. The greatest thickness of each formation, as at present known, is:—KURNOOLS, 1,200 feet; KUDDAPAHS, 21,000 feet.

The most interesting feature about these formations is that they are most probably representatives of the great VINDHYAN series of Indian rocks. This conclusion has been arrived at from careful comparisons of typical rock-specimens from either series, and of the recorded observations made during the surveys of each. The VINDHYANS have now been traced as far south as the Godavery river, where it traverses the district bearing its name; and here they are so lithologically and stratigraphically like the KUDDAPAHS and KURNOOLS on the Kistnah river, not very far south, that there hardly remains a doubt as to the identity of the one with the other.

The history of the KUDDAPAHS is still to be thoroughly worked out; and on this account, the present sketch will be more directly confined to a description of the KURNOOLS. There are, however, some well-marked and clearly made out features of the KUDDAPAHS which may in the mean time be adverted to.

Both formations agree in this, that they are largely made up of buartzites, while limestones are sparingly developed in one and extensively in the other; but the KUDDAPAHS are distinct in showing strong groups of clay-slates, with one of which it may be necessary eventually to include the trap-flows and their associates referred to above.

Supposing at present that all the quartzites, slates, &c., not included in the following description of the KURNOOLS, may be considered as of the KUDDAPAH FORMATION, it is then possible to give an idea of their locality in the great area of country occupied by this formation.

The Goolcheroo hill-ranges south of Kuddapah, and their extension south-eastward down to Triputty and the Naggery hills, are made up of quartzite sandstones and conglomerates; while rocks of the same kind with bands of slate go to form the long range of the Eastern Ghats or Yellacondas lying between the Kuddapah and Nellore districts. The country south-east of Kuddapah, that is Ontamitta, Chitwail, Poolumpet, &c., within these mountain ranges, and that due north of it:—Nullamullays, Budwail and Cumbum, up to the Kistnah river, are also made up of like rocks of the same formation. The Gundicottah range of hills, north-west of Kuddapah, is likewise of these old quartzites, and the parallel ridges and valleys between that range and the Bellary district to the west, with their extensions right up to Jaggarnat-Conda (hill), a few miles south of Kurnool, are of quartzites, slates and traps.

These older rocks are interesting as being traversed, at rare intervals, by veins and strings of copper and lead ores, accounts of which have from time to time been given by writers on the resources of Kurnool and Kuddapah. Copper ore occurs very sparingly; in fact, there are only traces of it, but the sulphide of lead is more abundant. The workings for both were abandoned years ago; a state of things perhaps due to the difficulties in the way of living at, and working the mines, rather than to a failure in the ore. Traces of these ores are also known in the older crystallines or gneiss, of the remainder of the districts.

With such a brief account of what is at present known of them, the KUDDAPAHS may be left for future description.

KURNOOLS.

This formation unfolds itself as a double series of groups of limestones and quartzites; the lowest beds of all being quartzites, as thus, in descending order:—

1.	Limestone group ...	... a. Calcareous shales. b. Limestones.
2.	Quartzite group ...	... a. Pinnacled beds. b. Plateau beds.
3.	Limestone group ...	... a. Non-calcareous shales. b. Limestones.
4.	Quartzite group ...	... a. Massive beds. b. Beds (containing diamond gangue).

* A peak of the Naggery range, about 40 miles W. N. W. of Madras.

These four groups are quite distinct, though conformable; they generally overlap each other in some part of the field, and they lie, for the most part, very much as they were originally deposited, viz., in great flat basins with edges slightly turned up,* or in very flat undulations, from which, however, the upper limestones are always denuded, leaving the quartzites exposed.

1st Group, Khoondair Limestones.

The uppermost group lies nearly all over the wide Khoond-air (river) valley which stretches northwards from Kuddapah town, and over most of the Kuddapah basin or southern extremity of this valley. There is a small outlier under the fort of Kurnool; while more of the same rocks cover the eastern extremity of the Raichoor Doáb. Again, a considerable detached area of these beds, with the other groups, occurs in the Palnád, or western taluqs of the Kistnah district.

The rock coming to the surface,† especially in the Khoond-air valley, is not, however, always limestones; more generally, there are reddish-purple calcareous shales (occasionally cleaved), and these constitute the upper member of the group. For instance, the shales occur all up the middle, and very strongly at either end, of this great valley. They gradually shade down into the typical limestones of the group, which are dark-gray, more or less earthy, sub-crystalline beds; sometimes very massive and thick, oftener flaggy or easily split up into flags of 1—3 inches in thickness. The limestones are also occasionally more crystalline and compact, and cleaved to a certain extent, where folding or crushing of the beds has taken place, as along the eastern side of the Khoond valley. They of course show most along the skirts of the valley, as near Kuddapah, Podatoor, Dhoor, Chagalmurry, Sirwél, and so on up to the banks of the Kistnah.

2nd Group, Paneum Quartzites.

Along the western side of the Khoond valley, the country rises very gently in a series of low long-sloping hills, with a few plateaus and undulations, which finally present an irregular scarp towards the Bellary district. These are the Gundicottah, Ramwarum and Paneum hills, whose surfaces, with the exception of the Gundicottah range, are made up of quartzites of the second group, which thus rises up from under the limestones of the Khoond valley.

This is the only side of this part of the country over which these quartzites occur; they do not appear on the western side of the valley, for the group thinned out altogether in that direction, as well as to the north and south; the sections among the turned up strata on this side showing the upper limestone group lying on the lower one without any intervening quartzites, as is the case in the sections on the western side.

Altered sandstones of the same group show rather strongly in the Kistnah district; where they are again, through the denudation of the upper limestones, the superficial beds of the low hills in the south-west corner of the Palnád.

The quartzites are of two kinds, quite distinct enough as features in the landscape, but hardly sufficiently so to be referred to as separate members of a group. The upper variety is a thick-bedded, massive, compact, white sandstone, much vitrified, but granular, and showing a very peculiar style of weathering into massive buttresses and pinnacles. The strata are generally horizontal, or at a very low angle, and the steep-sided ravines and scarps denuded in these are often fringed with strangely picturesque masses of rock, or the slopes below the scarps are strewn with great fallen masses of the same beds. The high-road from Kurnool to Nundial passes over a plateau of those white quartzites, and the quaintly worn masses immediately remind one of some rocky coast from whence the rushing and tumbling waters have long since retired.

Coarse sandstones and grits, with pebble beds, of dark colors, and in thinner strata are generally found subjacent to the thick, white, pinnacled quartzites, and are often alone without the covering of the upper beds. In such last cases, the remaining beds now form the summits of a number of flat-topped hills fringing the Koilkoontla and Banaganpilly sides of the Khoond valley.

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* The subjacent Kuddapahs are, on the contrary, turned up on end, convoluted, crushed, and faulted in the most varied way.

† The Khoond valley is very extensively covered with cotton soil.

3RD GROUP, JUMMULMUDDAGOO LIMESTONES.

Wherever the above group of quartzites has been cut through, it is seen to be resting quite conformably on a thick series of shales and limestones; occasionally the shales thin out and nearly disappear altogether, and then the quartzites look to be resting directly on gray limestones.

These constitute the second limestone group among the KURNOOLS, and they are generally easily distinguishable from those of the Khoond valley. The shales are generally of a buff color and are never calcareous, while the purple shales of the upper group are always more or less so; and again the limestones are as a rule more crystalline and compact. There are, it is true, just as earthy and flaggy beds to be found in the upper as in the lower group, but such beds are less frequent in the latter, and they are arranged in definite succession. There is generally a three-fold series, thus:—at the bottom, compact, sub-crystalline gray, and some purplish beds, with a thin series of peculiar limestone breccias; in the middle, thick, compact-splintery dark-gray and blueish beds; and thirdly, pale and dark-gray compact, sub-crystalline and sub-earthy, often flaggy, beds.

The more crystalline and compact beds weather in a peculiar coralloid manner; the worn surfaces being so radiately furrowed, pitted, and concentrically terraced, that the rock seems to be made up of two or three different forms of coral; but close examination has failed to show any organic structure. This coralloid appearance is characteristic of any great show of these lower limestones, though the same feature is also seen every now and then in the upper group.

This generally more crystalline set of limestones is seen at intervals, along the eastern side of the Khoond valley, in a narrow belt of outcrop at or near the western base of the Nullamullays. Again, on the western side of the same valley in Koilkoontla and Banaganpilly, and in the valley between the low Nosoom ridge and the Gundicottah hills, and so further south, in the western part of the Kuddapah basin, where the Nerjee quarries* have been opened up in the thin and compact beds of the group.

In the steep western slopes of the Gundicottah, Ramwarum, and Paneum ranges of hills, these limestones again come to light and form a narrow continuous terrace below the vertical scarps of upper quartzites, all the way from the tops of the hills east of Tadpurthee (Bellary district), up to within 24 miles south-south-east from Kurnool, when it spreads out in wide sheets between the lower and gentler undulating hills which are here sinking down to the flat country of Kurnool, itself built on a further out-stretch of these same beds.

Here, in Kurnool, the group has thinned out a great deal, but still there are the three varieties of limestones in their proper order: the canal being cut in thin flaggy upper beds; the more crystalline strata cropping out between the canal and the village of Calloor; and the thin grey compact sub-crystallines, though altered much by local igneous action, showing close under the western bastions of the town. Thence, with the exception of some slight denudation in the Toongabudra and Kistnah, these limestones extend northwards to a few miles beyond the latter river, in the Hydrabad territory.

In the Palnâd there is the limestone again in great force. It here presents identical characters with those in Kurnool and Kuddapah, except that it is more extensively cleaved; and that the white and buff non-calcareous shales are only seen to a small extent.

4TH GROUP, BANAGANPILLY QUARTZITES.

Lowest of all of these strata comes another quartzite group which is interesting as including the beds from which only diamonds are known to have been extracted in the districts under description.

Hence, if the old nomenclature of "diamond sandstone," or "diamond formation" was to be employed in a classification of Madras rocks, it would have to be applied to the KURNOOLS, or one of the groups included in that formation. There is no case known of diamonds having been found in quartzites of the KUDDAPAHS, or in fact in any other group of

* These quarries were opened, and are now extensively worked by E. W. Barnett, Esq., who has used the stone whenever practicable on the Madras Railway, and for the new Madras University and other public buildings in the Presidency.

quartzites but the one now described. It is not, however, advisable to employ a name to distinguish a formation, which is derived from what is evidently only an accidental attribute of the rocks; while it is not certain that the diamond sandstones of Punna in Central India, which belong to the VINDHYAN SERIES, are on the same geological horizon as the diamond-bearing beds in the KURNOOLS.

This group of quartzites is a generally thin series of coarse sands, grits, and pebble beds, of dark colors; the sandstones being in thick beds, while the grits, &c., are generally thin and sometimes flaggy. The pebble beds are full of small fragments of chert of various colors which are evidently derived from the slates and trappean beds of the KUDDAPAHS, on the up-turned edges of which they now rest.

The relations and constitution of the group were first made out at Banaganpilly in the Kurnool district, where the long sloping hill which rises to the west of the town is faced with the quartzites.* From this point the strata were traced to the west, on either side of the Puspulla valley, as another narrow terrace of nearly horizontal beds of not much thickness, below and continuous with the terrace of limestones of the second group, already referred to as lying below the western scarps of the Ramwarum and Paneum hills. Indeed, these lowest quartzites form the toe of these western slopes.

The thin-bedded pebbly strata which are generally the lowest in the group seem to be the holders of the gangue, or shaly seams, in which the diamonds are found, but it is only at rare intervals in the exposed area of these pebble-beds that workings have been opened, which is partly accounted for by the fact that these seams of sandy and pebbly shales are only of local occurrence in the quartzites. The selection of working sites seems mainly to have been guided by chance, as the finding of a diamond by a cooly or shepherd, and the selection has been a lucky one in only some cases, for there are localities where extensive workings have evidently been carried on for centuries; while others have soon been deserted. The diamonds found at present are very small and not of much value, nor do the returns seem to have been any better for many years. The workings are of two kinds; mines excavated in the strata, or pits sunk at various points in the recent deposits of dèbris, shingle, and gravel, derived from the denudation of the quartzites.† The Banaganpilly workings are mainly mines, while the now deserted pits at Chennoor near Kuddapah were in recent gravels.

In the Palnad,‡ there are again a set of altered sandstones answering to this group, and there too among these beds are frequent traces of old diamond workings.

The lowest group of the Kurnool formation is always found to be resting unconformably on other quartzites, slates, and limestones; and where it is overlapped by the superincumbent limestones, these in their turn are found covering the older rocks in the same way; in fact, there is not the smallest doubt but that the four groups now described constitute a distinct formation separable by a great interval of time from the subjacent strata, or the KUDDAPAH.

Both formations are totally devoid of any fossil remains, at least not a trace of evidence of organic life has been found in their strata, and in this they are like the VINDHYANS which are as indicative of a period when there was no life. No more likely series of rocks for containing such remains could be imagined; and one is tempted again and again to examine favourable localities, but always with no other result than some deceptive concretions, or worm-like tracks, or the most perfect surface of ripplings in the sandstones.

Neither can it be that fossil remains which may have once existed can have been so completely obliterated by the metamorphic influence to which these rocks have been exposed, as to have left no trace behind; for whenever we have the originally sedimentary contritution of the rock apparently completely baked out of sight, as it were,—as in the case of pebble beds and the coarsest conglomerates, which, until they are weathered, are as uniformly granular quartzites as one could wish to see—, the various weathering influences have again revealed the original constitution.

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* The Banaganpilly diamond mines are sunk and worked on the slope of this hill.

† These dèbris-deposits are often quite outside the area of KUDDAPAHS and KURNOOLS, and hence we occasionally hear of diamonds being found in the neighbourhood of granite, or gneiss, when they are supposed to be derived from the latter rocks.

‡ It may be as well to notice that the so-called Juggiapett coal-field is a north-easterly extension of the Palnad area, and the Juggiapett rocks are KURNOOLS and KUDDAPAHS which are not at all of a coal-bearing character.

There are deceptive appearances of organic structure, such as, minute concentrically laminated globular bodies, in some of the KUDDAPAH rocks; the coralloid character of the Kurnool limestones; minute *Cypris*-like bodies in the upper limestones; the dendritric crystallizations of the oxide of manganese in quartzites, limestones, and slates; and lastly the cavities of clay-galls so frequent in the sandstones; but these of course are all referrible to other than organic origin.

GEOLOGICAL SKETCH OF THE SHILLONG PLATEAU: *by* H. B. MEDLICOTT, F. G. S., Geol. Survey of India.

The main features of the geology of the Shillong plateau, on the north-eastern frontier of Bengal, have been known for some time: cretaceous, nummulitic, and younger strata, resting horizontally upon metamorphic rocks of various types, at an elevation of 4,000 to 5,000 feet, and doubtfully related to extensive masses of trappean eruptive rocks. A brief opportunity has recently occurred of visiting the hitherto geologically unexplored western portion of the plateau in the Garo region; and also of re-examining the central portion, in the Khasia district, *at a season when field work was possible.* A brief abstract of the results is here given in anticipation of the more detailed description.

Regarding the supra nummulitic rocks, which are very poorly exposed in the central region, little fresh information has been gained. From the sandstone of Nongkalong on the western limits of the Khasia district, where it rests upon nummulitic limestone, Captain Godwin-Austen has made a collection of fossils upon which Dr. Stoliczka remarks that "none of the species, so far as recognizable, appear to be identical with those known from the nummulitic beds of the same district."

The nummulitic formation presents a total change in the character of the deposits from east to west: from being purely sandy and calcareous, they become almost entirely argillaceous.

The doubtful horizon between the nummulitic and cretaceous formations has been worked out. The former does not overlap the latter; the northern outliers, so far as known, are all of the cretaceous deposits.

The local order of the cretaceous deposits at Cherrapoonji is described.

Many of the fossils collected have been identified by Dr. Stoliczka with forms occurring in the Ootatoor and Arrialoor groups of the upper cretaceous rocks of South India. In the small collection obtained, there were recognisable eleven forms of Cephalopoda, twenty-seven of Gastropoda, eleven of Lamellibranchiata, three of Brachiopoda, and four Echinoidea.

A very extensive formation of stratified eruptive rocks is exposed, unconformably overlaid by the cretaceous strata and resting in natural junction against a steep face of the metamorphic rocks along the south base of the plateau. It is fully 3,000 feet thick. No inter-trappean sedimentary rocks, nor any infra-trappean younger than the metamorphics, having been found, it is impossible to assign the age of this eruptive formation. It is proposed to call it the Sylhet Trap.

Totally distinct from this is the Khasia Trap, so massively developed in the interior of the hills, associated with the younger metamorphics. It is probably hypo-synchronous with these, *i. e.*, introduced (? formed) at the time of their main disturbance and metamorphism.

The granite occurring, both in large masses and in dykes, through the upper metamorphics is younger than the Khasia Trap.

The separation of the Shillong series (the upper metamorphics) from the Gneissic series, is conjecturally indicated.

The peculiar position of the plateau, between two great regions of disturbance, and the close relation of the stratigraphical features with the south-eastern of these mountain-regions are discussed as illustrative of current opinions upon crust-movements.

The occurrence of a sharply defined terrace of older alluvium round the west base of the Garo hills, and corresponding with the well known Madhoopoor jungle deposits in the plains to the south, is noticed with reference to the changes that have affected the delta of the great rivers.

October 1868.

ON THE OCCURRENCE OF GOLD IN THE DISTRICT OF SINGBHÚM, &C., BY VAL. BALL, ESQ., Geological Survey of India.

The existence of gold in the districts of the south-west frontier of Bengal and in the neighbouring tributary states has long been known. It is found not only in the sands of many rivers and streams, but in some instances it has been mined for in the alluvial and other superficial deposits.

Colonel Haughton in his interesting memorandum 'On the geological structure and mineral resources of the Singhbhúm Division,* has given an account of the gold washing, and enumerated several localities where gold mining had been, or was, at the time of his visits, carried on. He also quotes from a letter from Mr. Robinson in which that gentleman states the results of his attempts to establish gold-mining under European superintendence.

At Rohobe in Oodipur where operations were commenced and shewed some prospect of being fairly remunerative, the climate proved so "hot and unhealthy" that it was found that no European could live there, and the works were given up.

Colonel Haughton says that "the metal was found some years ago in considerable lumps "in the Sona Nuddee of Sonapet in Tamar on the northern extremity of Singhbhúm, "and much is still found there."

I have invariably found that the washers have traditions of nuggets having been found at intervals.

The cases of the gold having been found *in situ* are undoubtedly rare. Colonel Haughton speaks of it occurring in *(in situ?)* "a little north of Assuntitlea in Khursowa," but further on he states "I have not heard of any instance in which the metal has been found attached to a stone, so that the former statement must only mean to imply that it is mined for in superficial deposits." Dr. Emil Stœhr states† that traces of gold were found in the copper ores of Singbhúm.

A Mr. Emerson was specially employed by the Singbhúm Copper Company to investigate the gold resources of the country. He is said to have crushed a quantity of quartz and to have found traces of gold in it; but his operations do not appear to have been sufficiently successful to encourage him to continue.

When in Chaibassa last April, I was shewn a small nugget of gold in a quartz matrix. It was said to have been obtained in the Kappergudee Ghat near Kalkapur in Dholbhúm.

It is not within the scope of the present paper to give a complete resumé of all that is recorded on the subject, but rather to give an account of what has actually come under my own observation in those portions of the districts which have been examined geologically.

During the season of 1866-67, Mr. Ormsby and myself fancied we were able to connect the occurrence of gold in the streams with the existence of certain submetamorphic rocks (magnesium and mica schists, slates and quartzites) which were then for the first time met with in Mânbhúm.

Being anxious to put this connection to as rigid a test as circumstances would admit of, and wishing to define, if possible, the exact boundaries within which gold certainly exists and may be reasonably looked for, I with some difficulty persuaded two gold washers (man

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* J. A. S. B. XXIII, p. 103, 1854.

† Einige Bemerkungen uber den District Singhbhum in Bengalen. Viertel Jahrs'schrift der Naturforschenden Geselschaft. Zurich, 5th year, Part 4, 1860.

and wife) to accompany me during my examination of the remaining portion of the district of Mânbhúm. They remained with me for upwards of three months, washing daily at such places as pointed out.

One of the most interesting results is, that the existence of gold in the metamorphic as well as the sub-metamorphic rocks has been satisfactorily proved. This, from various reasons, I was not prepared to expect. Colonel Haughton, who speaks of the granitic gneissose rocks as *igneous*, states that gold is never found in the streams traversing them. Again, the Natives, so far as my experience goes, do not wash in the sands, &c., lying on the metamorphic rocks, although they do not connect the existence of gold in the sands with the vicinity of any particular rock.

In Mânbhúm, the experience of generations of washers has enabled them to define the boundaries within which washing is remunerative; and this boundary, it is interesting to observe, corresponds on the north exactly with that of the sub-metamorphic rocks.* This coincidence I ascertained in the following manner. On my arrival at Dulmi (which is situated on the faulted boundary of these two groups of rocks) when marching northwards from the lower part of Pattrum, the gold-washer asked to be allowed to return to his own country (Dhalbhúm), stating that none of his race ever went north of Dulmi. I induced him however to stop, and while we remained north of the fault the washings were carried on in the granitic gneiss area with comparatively poor, but not exactly barren, results. On the day I crossed the fault south of Sindaree, when returning southwards, the gold-washer said that we should after that find gold more regularly and in greater quantities than we had done since we came north at Dulmi.

During the whole time, a record was kept of the daily results and of the nature of the rocks in which the washings were made. The following abstract will suffice for comparison of the productiveness of the two formations:—

Sub-metamorphics.

	January.	February.	March.	April.	TOTAL.
Number of days on which washings were made	31	9	18	[illegible]	66
Unsuccessful days	2	3	2	2	9 = 3·6 per cent.
Gold in grains	17·68	4·65	7·6	2·45	32·38
Daily average in grains ...	·57	·516	·4	·3	Daily average for whole period = ·46 grains.

Metamorphics.

	January.	February.	March.	April.	TOTAL.
Number of days on which washings were made	......	20	13	......	33
Unsuccessful days	......	13	9	......	22 = 66 per cent.
Total gold in grains	......	4·78	·7	......	5·48
Daily average	......	·23	·05	......	Daily average for whole period $= \frac{5·48}{33} = ·16$.

* A line drawn across the southern part of Mânbhúm from Simlapal on the east through Burrabazar to a little north of Echagurh on the west, roughly indicates the position of the line of boundary between the two formations.

Comparing these results by the number of successful days first, we may say, that for gold producing, the submetamorphic rocks are to the metamorphics as (100—13·6=)86·4 to (100—66=)34=2·5 : 1; comparing by daily average, the proportions become ·46 : ·16=q. p. 3 : 1.

We may therefore conclude that the submetamorphics are between two and half and three times as productive of gold as the metamorphics, so that as the gold washers only find a subsistence from washing in the submetamorphic area, it is obvious that it would not pay them to work in the metamorphics.

The greatest amount found on one day was 2·2 grains, but the daily averages given above should not be taken as indicative of the amount of gold to be found by a regular system of working where the washers would of course be set at favorable spots, and would not have to spend a considerable portion of their time daily, as was the case of the men I employed, in making marches before they reached the scene of their labours.*

Various papers in the Asiatic Society's Journal describe the methods of gold-washing practised in different parts of India. The instruments used, though essentially the same in principle throughout, have local peculiarities of shape, &c., and the manner of manipulation also varies.

At Heera Khund† the same instrument and manipulation serve for the separation of both diamonds and gold. In fact the diamonds are found in the middle of the process, the iron sand with specks of gold being the final residue.

In Mânbhúm and Singbhúm the instruments used are perhaps more simple than those used in any other place. The dish measures 28″ by 18″, it is hollowed somewhat eccentrically to a maximum depth of about 2½ inches. A scraper formed of a flattened iron-hook set in a handle, serves to collect the auriferious sand and gravel which accumulates in the angles of the rocks in the beds of streams. The dish when filled is placed in shallow water, and the operator working with his hands soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions.

The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion of the remaining gravel, and the process is completed by a circular motion, which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron-sand in which the specks of gold are readily apparent.

The gold-washers belong to the lowest and poorest races in the country, Gassees according to Colonel Haughton, but some of those which I met with were a race of kumars, called Dokras. Their numbers have been greatly reduced by the famine; without exception they are all in the power of the Mahajuns, for whom they work at a low rate, and are never able to free themselves of the claims which the Mahajuns make on account of advances.

The daily earnings of the gold-washers are small, but might no doubt be increased, if it were not that they are always satisfied when enough gold has been found for procuring the day's subsistence.

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* It is conceivable that the fact of the greater quantity of gold being found in the superficial deposits within the submetamorphic area might be atttributable to something in the configuration or elevation of the ground conducive to the greater accumulation of gold within that area. I could not however discover anything of this kind; the fall to south is gradual throughout both formations.

The origin of the gold which is annually found in the rivers at present is, I believe, twofold. A portion being directly derived from the rocks and the remainder resulting from the re-assortment of detritus which is the remanet of sub-aerial action.

In both formations, the evidences of extensive sub-aerial action are numerous and prominent, and it is obvious that nature has been carrying on gold washing operations in the valleys, since denudation first commenced to scoop them out, leaving barriers of intervening ranges of hills formed of the hardest rocks between them.

† J. A. S. B. VIII. 1057, 1839.

Colonel Haughton says—"The Gassees can always reckon on earning from three to four pice per day, and I am assured that a vigorous man often gets as much as twelve annas, which, as the ordinary rate of field labour is about one pice, must be considered a very large sum."*

Mr. Robinson found in a trial which he made at Rohobe in Oodipur, that men to whom he paid one anna could produce for him from three to four annas worth of gold.

Colonel Dalton states that the washers themselves regard it as a very poor trade, simply yielding they say *pét bur* (bellyful).

Dr. Stœhr in his paper on Singhbhúm states that he found the average daily earning to be about 25 centimes (rather more than an anna and a half).

The men I met with stated that they could earn about an anna a day and occasionally three or four annas.

Taking into consideration the manner in which the gold is distributed through the superficial deposits of these districts, it would seem that the system of hydraulic mining, at present practised in California, is the one which would be most likely to be successful.

In a recently published account† of that system we learn that there is a company in California which supplies water to the miners at such a moderate rate that "350 miner's inches of water, with a head of 160 feet, will remove and wash 4,000 tons of gravel per diem, leaving a small profit on the working of stuff affording gold to the value of only three half pence per ton."

In parts of the districts under consideration it would be hopeless to expect to obtain a constant and sufficient supply of water with the necessary head-way: but there must be many places at the bases of the plateaux which rise towards the west, where the conditions would be peculiarly favourable. During the rains the number of such places would of course be vastly increased.

The simplest idea of this process, which seems so nearly to approach to perfection in California, is not, however, altogether unknown to the natives. Mr. Robinson says‡—"Another plan and a very remarkable one in which the people collect the gold is by drawing up small watercourses before the rains, so as to make places for a deposit of soil carried down by the water; this soil is cleared out several times and in it is found a large deposit of gold."

In the shallow diggings the hydraulic system would not of course be applicable, but even in them an increased field would undoubtedly result from supplanting the native's dish by the Californian pan, rocker, long-tom and sluice.

September, 1868.

MEMORANDUM ON THE WELLS NOW BEING SUNK AT THE EUROPEAN PENITENTIARY, AND AT THE SITE FOR THE CENTRAL JAIL, HAZAREEBAGH, *by* H. B. MEDLICOTT, F. G. S., GEOLOGICAL SURVEY OF INDIA.

1. All the rocks of Hazareebagh are of the most extreme metamorphic type, and are besides very irregularly arranged. It will, therefore, be at once understood that a question of water-supply, in which these rocks are concerned, is altogether beyond those simpler cases where a study of the sections might enable a Geologist to give an approximate positive judgment upon the source of water in any given position. The independent method being thus not applicable, I had to trust to the discussion of existing local experience, and the comparison of this with the special cases proposed, with the following results.

2. Hazareebagh is on an undulating upland. There is nowhere any strictly level ground; but the tops of the ridges are generally very flat, and the slopes very gentle. It

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* J. A. S. B., 1854, p. 109.

† Quar. Journal of Science, XIX, July 1868.

‡ J. A. S. B., 1854, p. 108.

is only in the immediate neighbourhood of the main stream-channels that rougher and steeper ground occurs, and also where rocks come to, or near to, the surface, whether on the slopes, or on the ridges. But even in this latter case, the summits of such ridges are very approximately on the same level as those where no rock is to be seen; I regret that available information does not enable me to give figures. Over large areas, as in and about the Station and Cantonments, no rock whatever is exposed. From the few glimpses I was able to get in the upper part of unlined wells or in ditches, it would appear that such areas are formed of a dark stiff sandy clay, tinted with iron, and mottled with concentrated granules of the same in varying proportions. The greatest thickness I was able to observe of this stratum was 14 feet in a partially dug well, where the water level had not yet been reached; but, no doubt, it locally attains greater dimensions. I could not fully satisfy myself, from an inspection of this clay, whether it is purely derived from the decomposition in place of the subjacent rock, or whether it be in some manner alluvial, a point that would bear importantly upon the under-ground distribution of the water. I incline to the former view; but, if correct, the rocks must be there unusually free from the quartz-veins which occur so abundantly in the exposed rock sections, and which veins would remain in position and unaffected in the clay. This stratum forms a cold and retentive under-clay: the upper two feet or so of a paler colour, where de- and re-composition has further advanced, forms a slightly improved sub-soil, yielding at the surface a very poor soil. Where the iron and the sand are not in excess, the under-clay forms an excellent brick-clay; the upper layer being fit for tiles. Below this clay, I am told, there comes suddenly an unknown thickness of incoherent sandy or gravelly material, in which the water runs freely; but from the very apocryphal descriptions I have received, I am quite unable to say whether this be a diluvial deposit, or merely disintegrated rock in place; what has been conjectured regarding the clay may show that I incline to the latter view: the evidence of any old heaps or of well-clearings is in favor of it. The greatly preponderating rock of the region is a finely granular hornblendic gneiss. From a list of measurements taken in 42 wells within Cantonments, and a partially contoured plan, both furnished to me by the Executive Engineer, I have made the annexed tabular statement, from which a few inferences may be gleaned. In none of these wells, that I could hear of, was anything like *rock* met with.

3. It is remarked on the list that "those measured in the evening have often been largely drawn upon, as No. 14 on the south side of the Plunge-bath. Early measurements for all would have been better, even if it had to be done on consecutive days; it would seem, however, that the discrepancies thus introduced may balance each other in the averages of the several groups; but the data being thus not comparable, and there being no collateral information, one is left without a clue to an explanation of what may be only apparent anomalies; such as Nos. 26 and 27, deep wells, exhausted, while much shallower wells in the same neighbourhood hold several feet of water. In all such statistics, the original depths to which the wells were sunk should be the measure given; this ought to be in a permanent record and with it some attempt, however rough, to describe the materials cut through. All should, moreover, be easily referrible to the level of the lowest drainage point of the region as a datum line.

4. The table, contrary to what might have been expected, shows no decided advantage in the supply to wells at a lower level.

5. There is a very marked advantage shown, as was of course to be expected, in an increase to the depth of the wells; there is at least 6 inches gained in the daily supply for every foot in depth below a certain point. I say *daily* supply, for I do not think that the depth of a well would affect its permanent level; thus Nos. 2 and 3 are within 70 yards of each other, neither was much in use; and although No. 3 is deeper by 8 feet 6 inches, there is only 1 foot 3 inches difference in the water level, and even this is in favor of the shallower well. From every consideration it is manifest to me that to have an unfailing supply of the best water in Cantonments, it is only necessary to sink a few feet lower than has been the practice, and, I might add, to adopt some less primitive mode of drawing water than that of hauling in buckets. Where there are only a few feet of water, this mode of raising makes it turbid and unfit for immediate use. Serious difficulty seems to have been felt in attempting to carry the wells even to their present depth; but I cannot find that any proper means have been tried to overcome this difficulty, such as the use of some method of shoring up the sides while the work is being carried on in friable, watery ground, and at the same time some means of unwatering more effectual than the obstructive one of baling and hauling.

6. Several figures in the list show how safely the water is stored below; how slowly, but surely, the supply recovers when drawn upon. These measurements were taken on the 5th of June, after a long season of drought. Dr. J. M. Coates, Superintendent of Jails, has kindly given me a statement of the rain-falls for the preceding months:—January, 0·26; February, 0·97; March, 0·64; April, 0·0; May, 1·54; up to 5th June, 0·59. The scarcity was much felt, but it was not an extreme case. I am told that worse seasons have been experienced, still there were 13 and 20 feet of water in wells Nos. 2 and 3 at a depth from the surface of 26 and 27 feet. In other cases, as Nos. 6 and 14, a fair daily supply was renewed nightly. The stratum of clay can be but very slightly permeable to water, and can contribute little; all the evidence goes to show that the water is lodged in the disintegrated upper portions of the under-lying gneiss. The depth to which this decomposition takes place is variable according to the variety of the rock in different spots; but it is generally very considerable, and in every case I would take that as the depth to which a well may be sunk with advantage. The moderate permeability of this rotten rock, as shown by the facts just quoted, suggests an alternative to the deep sinking which has been recommended as the best safeguard against scarcity: it would seem that wells may be sunk within 80 to 100 yards of each other without seriously affecting the daily supply in each within the limits of ordinary demand.

7. In connection with the question here discussed, I would bring to notice an allied one of equal importance. In the 13 days following the 6th June there fell 14·43" of rain, and all the wells were filled to within a foot of, or were quite up to, the surface. This is their condition for months throughout the rainy season, after which they slowly subside to their minimum at the end of the ensuing hot season. Such a state of things will seem strange after what has been said of the configuration of the ground, that the surface drainage is ample in every direction; and that at no great distance the rocks outcrop in valleys much below the general level of the country, unless from artificial causes there is no surface lodgement of water. It may seem stranger that it should be allowed to remain so. I have lately heard doubts expressed as to the reputed healthiness of Hazareebaugh. Without in the least wishing to endorse such an opinion, against which there is much presumptive evidence, I may remark that, according to received notions, it seems like neglecting a means of improved healthiness to allow the water to be so near the surface. It may be said, and I am not prepared to deny the assertion, that so long as the water is even a few inches under ground, it is innocuous; that it is only when allowed to stagnate on the surface that it becomes injurious; if it be so, most of the ground would require no treatment, but there would remain much to be done. When I passed through Hazareebaugh in the middle of November 1866, after we had many days of hot sunny weather, I noticed soft sludgy ground in many places, even within a short stone's-throw of the barracks. At half-way down the slopes of the shallow hollows the water does ooze out, creating this boggy ground, so long as the general water level remains above the level of the channel. Surely this would come within the limits of the conditions to which the autumnal unhealthiness is attributed all over India. But here, not as in the cities of the plains, the remedy is easy; the most complete facilities exist for drainage of any required degree. Of drainage, such as is usually understood in India, Hazareebagh has had its fair share: the natural water channels and the cuts along the roadside, or elsewhere, are kept clear, but in such a sub-soil as that here the effect of this is imperceptible. Drainage to be effectual should be such "thorough drainage" as a farmer would apply to similar land in Scotland, if he wanted to bring it under tillage.

8. The Civil Station adjoins Cantonments immediately on the north-west, the ground being apparently slightly higher. Here, about the Zillah Jail, and in the grounds of the house occupied by the Superintendent of Jails, I saw some sections in unlined wells somewhat different from what would seem to be the rule in Cantonments, in so far as that the clay, which is of precisely the same character as elsewhere, is much less thick, not more than 6 to 10 feet. The rock does not appear at the surface. Even here I could not satisfy myself upon the mode of origin of the clay; there seems to be generally at the base a foot or so, in which coarse quartz debris is abundant and irregularly scattered. Here, however, it is certain that the water-yielding rock is the porous rotten gneiss, in which the wells are dug without any difficulty. It is often so loose as to crumble away and fall in.

9. We may now come to the main object of our investigation. The European Penitentiary stands about three-fourths of a mile to north-north-east of Cantonments, and separated from them by a broad valley, some 40 feet deep, passing up to westwards, in which

direction the ridges are confluent. The site for the Central Jail is some few score yards beyond the Penitentiary, on another minor branch of the same system of ridges. In both localities rock crops out freely in many places, and it might have been anticipated from the beginning that the well question would assume a very different aspect from that of any case within local experience. It were useless to moralise upon so common an occurrence as want of foresight, or to indicate its source in this particular instance.

10. In the Penitentiary well there is no clay at top. After about 3 feet of coarse quartz gravel, mixed with red sandy earth, they come upon a run of largely crystallized granite (pegmatite) very irregularly associated with hornblendic gneiss. At first this mass was not difficult to be cut, although not nearly so soft as the rotten rock already spoken of, but it rapidly became harder, and at about 20 feet blasting had to be resorted to. All effects of decomposition from surface atmospheric influence having ceased, the stone showed its true characters of intense hardness and complete impermeability. The arrangement of the bedding, if, indeed, it be true bedding, in this short shaft is exceedingly irregular, at one spot apparently dipping to the north, and at another to the west. In the hard rock at base there are some well marked joint planes showing large flat surfaces nearly vertical, but these joints do not seem to be available for the percolation of water; the few leakages that occur are from points in the indefinite cracks that traverse the stone discontinuously without any system, and generally where there is a film or layer of partially disintegrated rock. Near the base of the shaft another vein of granite like that at top, but thinner, traverses the gneiss irregularly at a low average angle, but here it is firmly united with the containing rock, the same even surface of fracture passing indiscriminately through both. I waited for several days to have this well emptied, but the water was still knee-deep at my last examination. I do not consider that I have lost any evidence of importance.

11. From the accounts I have received, there would seem to be some prospect of immediate success. I am informed by Dr. Coates that a few days before the work closed at the end of the hot season, he made a rough measurement of the leakage water, and found it to be about 40 gallons per hour, nearly 1,000 per day. I confess that this surprises me much: the excavation then was at about the level the water stood at when I saw it last, and the leakage did not seem to me any thing like so much, although the time of year was so much more favorable, and the well had just been emptied by double gangs of men working day and night. Subsequent to that measurement, the last few blasts put into the rock disclosed one or more layers much softer than any met with for some yards above, and from which water flowed in much greater abundance than from any of the higher points. Unfortunately the rains put a stop to the work before this ground could be fully proved. The only symptoms I could detect of these sources was that, in walking about through the water, I felt at two or three spots a very appreciable warmth under my feet. The first thing to be done now is fully to test this ground. Five or 6 feet more of cutting ought to prove what it is worth. But a large margin ought to be left above any measurement made now for the diminution that may be expected in the dry season.

12. There can, of course, be no doubt of ultimate success: accumulated drippings will at last yield the required supply. But this must remain matter of experiment. No one but a diviner would venture to predict at what point success would be attained in rocks like these. There is, however, an evident choice as to the direction in which these contributions are to be sought. That word "spring" has a great deal to answer for: most men seem to think that water comes from the bowels of the earth, whereas in 99 out of 100 apparent cases the source is from above. The only available, and the only known, source of water here is the one already pointed out, the porous mass of disintegrated rock at the out-crop under the clay. This being the case, I would decidedly recommend, in the event of the next few feet in depth not giving the required supply, that the vertical shaft be changed for a nearly horizontal drift. The chances are almost all in favor of this plan, and there is here the ultimate certainty of tapping the source itself in the most effectual manner from below. In the vertical shaft there is no doubt the chance of contributions from every side, while in the drift we must select the most likely direction, but I am in favor of this attempt. There are two elements for consideration, the structure of the rocks, and the lie of the surface. From what has been seen of the rocks in the Penitentiary well, there is little or no room for choice; they have no definite arrangement. The most frequent run of the rocks in this neighbourhood is about north-north-west, and so the most likely line to cut them would be at right angles to that direction. The *primâ facie* view of the second condition would

suggest to make straight for the nearest point of the slope of the ridge, but it must be modified in this case. I have carefully examined the line of the surface, and should consider that course to be unsafe; the slope to the south is too near and too rapid. The ground from which a supply is to be expected lies to the west and west-south-west. I would recommend that the drift be cut to west-30°-south, with a rise of 1 in 20. This direction, too, would approximately suit the probable run of the strata.

13. There is at least one advantage in having the well in solid rock; it may be left with its present full width, and only cased for 20 feet or so from the surface. I would recommend that this be done at once; and that the pump, by which it is to be hoped the future water-supply is to be raised, be put in position now. In such a well, too, the work can be continued at any time as well as at first, should a season's trial prove the supply to be insufficient. I would not, however, let this be an excuse for an incomplete job at first; the failure would, of course, occur in a season of extreme drought, and might be seriously felt. But, indeed, the energy of Dr. Coates has provided an excellent resource for a time of such need, by converting the unsightly and doubtfully salubrious ravine in front of the Penitentiary into a most picturesque lake of deep water. A very little care on the part of the authorities can prevent any possibility of its becoming unwholesome.

14. The case of the Central Jail well is quite analogous to that of the Penitentiary, but a little more puzzling. Here too, however, I would recommend the prosecution of the work. I believe that success can be secured at a much less cost than would be entailed by abandoning the site upon which preparation and work has been already so far expended. At top there were 6 to 8 feet of red gravelly earth, resting on the edges of the strata, which are thoroughly disintegrated for 3 to 4 feet passing down into much firmer rock. Unlike in other wells the beds here have a steady dip of 40° to north-35°-west. At a depth of 30 feet on the rise, and 38 on the fall, an intensely hard rock was encountered, in which the work now stands at 40 feet. This well also had just been unwatered; and considering this, and the time of year, the leakage appeared to me to be very trifling. The last rock cut in this well is exceedingly unpromising; the large surface of it now exposed does not show a single crack or crevice. It breaks with sharp edges and large conchoidal fracture: it is a fine grained mixture of hornblende quartz and felspar thoroughly crystallized; superficially it might be described as a granitic diorite; but geologically it must come under the genus gneiss, as it seems to be strictly in the bedding, and to be simply an exaggerated form of the fine foliated hornblendic gneiss of the district. A correct knowledge of this rock would greatly help a decision regarding the well; but very little can be discovered; there is no out crop of it to be found. On the other side of the Penitentiary, at the edge of the upper lake, an exactly similar rock is exposed for fully 10 yards across its strike. Thus in the well shaft there is a prospect of having to cut through an indefinite thickness of perfectly barren rock, and of the most difficult nature. The same obstacle affects the consideration of a drift. In this position, also, the condition of the surface is of dominant importance on account of the rapid fall in certain directions. The most likely direction for a drift to intercept an abundant supply of water would be about due south, but this would take it into the same rock, and even for a greater thickness than in the shaft, the cut being oblique both to the strike and the dip; here, however, there would be the prospect of its becoming softer at every step. I have no doubt of this being the safest course. The lower the inclination of the drift, the better the chance. I would not advise a greater slope than would ensure the flow of water to the shaft. By cutting the drift to northward, it would run towards a convex bend of the ridge, and success would not be so secure; but the obnoxious rock (at least this bed of it) would be avoided.

15. There is one well in a position to be compared with these. The well for the Police Barrack stands nearly centrally on the ridge of which the new buildings occupy prolongations: it is 470 yards to west-18°-north from the Penitentiary well (the distances are taken from a plan lent to me by Colonel Dawson) and 1 foot 9 inches higher; the same well is 700 yards to south-42°-west from the Central Jail well, and 4 feet 6 inches above it. It is 30 feet deep. I have had very different accounts of this well: like all the others, it fills to the brim in the rains, and some say that it has a constant supply, the demand upon it not being very great; while others declare that it fails; that in the hot weather people living along side it fetch water from a considerable distance in the hollow. Some measurements of these three wells are given in Table II. The water in the two new wells on the 10th October was probably below what they had contained at their fullest; but even that

quantity shows that on the 19th June, when every other well in the place was at its full, these were still at least 10 and 6 feet below their minimum height, an indication of the slow and circuitous percolation by which they are fed.

I have made this report rather long, but I thought it best to omit nothing that might give information.

23*rd November* 1868.

TABLE I.

Table of depths of Water and of Wells in Cantonments as measured on the 5th June 1868, *just before commencement of the rains, grouped according to levels of sites.*

Number of Well.	Over 88′ contour. Depth		Between 88′ and 84′ Depth		Between 84′ and 80′ Depth		Under 80′ Depth		Remarks.
	Of Water.	Of Well.	Of Water.	Of Well.	Of Water.	Of Well.	Of Water.	Of Well.	
1	7·6	37·0	...	...	...	...	...	...	
2	13·0	38·9	...	...	...	...	...	...	Within 210 feet of No. 3.
3	20·1	47·3	...	...	...	...	...	...	These two wells were little used.
4	...	...	7·5	32·6	...	...	...	...	
5	...	...	5·1	35·3	...	...	...	...	
6	...	...	...	...	1·3	32·5	...	...	Much used.
7	...	...	...	...	1·4	19·8	...	...	
8	...	...	...	...	3·0	17·75	...	...	
9	7·0	37·3	...	...	...	...	...	...	
10	9·1	40·3	...	...	...	...	...	...	
11	...	...	2·9	35·5	...	...	...	...	
12	...	...	...	...	5·0	34·5	...	...	
13	...	...	3·3	32·5	...	...	...	...	
14	...	...	2·0	38·0	...	...	...	...	Much used.
15	...	...	...	...	...	...	6·9	30·25	
16	...	...	7·0	35·5	...	...	...	...	
17	...	...	7·7	31·1	...	...	...	...	
18	...	...	...	...	...	...	1·8	20·5	
19	...	...	3·0	30·0	...	...	...	...	
20	...	...	1·5	39·5	..	...	...	...	
21	...	...	...	...	...	...	7·5	36·6	
22	...	...	...	...	..	...	5·2	31·8	
23	...	...	...	...	...	...	5·5	32·5	
24	...	...	...	...	...	...	2·0	25 0	
25	...	...	...	...	...	...	3·25	27·25	
26	...	...	...	...	...	...	0 3	34·25	
27	...	...	...	...	...	...	0·3	31·25	
28	...	...	...	...	...	...	2·5	33·5	
29	...	...	...	...	...	...	4·5	33·5	
30	...	...	3·0	25·0	...	...	...	...	
31	...	...	...	...	...	...	1·4	19·0	
32	...	...	...	...	...	...	4·3	24·3	
33	1·0	29·0	...	...	...	...	...	...	
34	6·2	38·2	...	...	...	...	...	...	
35	2·2	24·2	...	...	...	...	...	.	
36	6·4	32·4	...	...	...	...	...	...	
37	9·2	40·2	...	...	...	...	...	...	The four last are within a radius
38	4·6	35·6	...	...	...	...	...	...	of 180 feet.
39	6·0	28·5	...	...	...	...	...	...	
40	0·0	21·0	...	...	...	...	...	...	Within 80 feet of No. 39.
41	7·2	32·2	...	...	..	...	...	. .	
42	0·0	29·0	...	...	...	...	...	...	The five last are within a radius Of 256 feet.
	79·5	442·8	43·0	304·0	10·7	104·55	45·45	379·70	
Mean of 13	6·1	34·0	...	...	...	...	...	...	Nos. 3 and 40 are omitted as
„ of 10	...	...	4·3	30·4	...	...	...	...	exceptional.
„ of 4	...	...	...	...	2·7	26·1	...	...	
„ of 13	...	...	...	...	...	...	3·5	29·2	

TABLE II.

Table of measurements in the new Jail Wells.

	Depth of Well.	Depth of Water on 19th June.		Depth of Water on 10th October.	
	feet.	feet.	inches.	feet.	inches.
A. Police Well	30	28	0	22	6
B. Penitentiary, 1′—9″ below A.	56	38	0	43	6
C. Central Jail, 4′—6″ „ „	39	21	6	31	0

METEORITES.—To the collection of Meteorites in the Geological Museum, there have been two valuable additions during the past three months. One of these, a specimen of the very interesting fall which occurred on the 11th July 1868, at Ornars (Doubs), in France, has been presented by M. Jules Marcou, Paris. It is a remarkable stone of a dark-grey colour, oolitic or sub-oolitic in texture, very friable, so as even to crumble under the action of the fingers. Iron is present in extremely small particles. It is very slightly magnetic. In fact, the fall represents a state intermediate between the ferruginous and the non-ferruginous falls, sp. gr. 3·599 (in fragments). It yielded to Pisani by analysis no less than 75·10 per cent. of Peridot. To the kindness of my good friend M. Marcou I am indebted for this interesting specimen.

The second fall occurred in India, near Mooltan, on the 17th October. The fall took place at a spot about 12 miles east of Lodran. "About 2 P. M. a loud report was heard "in the sky to the westward, and immediately a cloud of dust rose from the ground. On "going to the spot the ærolite was found. The sky was quite clear at the time." This is the account given by Captain Bond, District Superintendent of Police.

A portion only of the mass was obtained and forwarded. It is a very beautiful stone, consisting of a large proportion of bright yellowish green olivine, the crystals of which are imbedded in a kind of crystalline net-work of brilliant iron. The stone is at present being analyzed, and the result will be given hereafter.—T. O.

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GOVERNMENT OF INDIA.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1869. [May.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1868.

In reporting the progress and doings of the Geological Survey of India during the year 1868, I shall take each branch of our labors in the same order as I have for the most part observed on former occasions.

Mr. W. T. Blanford has, during the whole of the year just past, been engaged with the Abyssinian Field-force, and since its return in arranging and examining the large collections he made during the expedition. Mr. Ormsby was compelled to leave for Europe early in the year, having suffered from exposure to the tropical sun. And Mr. Charles Oldham left on furlough in November. On the other hand, Mr. Tween returned to his duty in charge of the Museum here. Mr. Foote resumed his labors in Madras, and Mr. Theobald in Burmah. On the whole our numbers have been, during the past year, less reduced than usual in consequence of ill-health.

At the commencement of the year, I proceeded to the Madras Presidency to make enquiry on the spot into the facts regarding the asserted occurrence of coal close to the town of Juggiapett, or Battavole, near the Kistna River. For years it had been persistently repeated that coal had actually been raised in that neighbourhood, and this statement was maintained notwithstanding the fact that very many persons, deeply interested in the result and most anxious to confirm the discovery if possible, had visited the localities, but had entirely failed to find any trace of evidence that coal existed or was likely to exist. Its occurrence in this place would have been of such high importance, that I was desirous of visiting the place as soon as practicable; I had also received from the Madras Government an urgent request to enquire into the facts. This request had reached me at a time when field-work was not practicable, but I had promised to go there as soon as possible. I left Calcutta, therefore, early in January; and accompanied by the original propounder of the discovery, I visited carefully every locality which he indicated, and went generally over the district. I regret to state that I found no trace of the coal-bearing rocks; no signs of coal, or of any of its usual accompaniments, nor was I able to see a single spot where anything, in the slightest degree leading to the conclusion that coal did exist there, could be found. On the contrary, all these rocks are an unbroken and uninterrupted continuation of similar rocks which cover an enormous area in the districts of Kurnool, Kuddapah, and Guntoor to the south, and which, thoroughly exposed as they are in their many folds, contortions, and disturbances throughout this area, must have exhibited any beds of coal or coal-shale which possibly existed. But, neither in the Juggiapett country, nor over the many hundred square miles to the south, over which similar rocks extend and which have all been carefully examined, has any trace of such deposits been noticed. I was, therefore, compelled to believe that the statement of coal having been found at or near Juggiapett was either based upon an intentional deception practised on the original observer, or was a delusion.

From the vicinity of Juggiapett, I proceeded southward, devoting some time to carefully testing the accuracy of the geological mapping of a considerable area which had been previously examined by Mr. C. Oldham and Mr. King, and returned to Calcutta.

Towards the close of the year (December), I proceeded to Attok to examine the rocks under the River Indus, through which a tunnel drift had been carried, with a view to determine the practicability of enlarging this drift into a regular roadway. I had wished to accomplish this work earlier in the season, but as the tunnel was full of water, and was not pumped out until December, I was obliged to defer it. Having already reported in some detail on this question, I need not here enter into the facts, further than to state, there appeared nothing either in the structure or in the composition of the rock-masses to prevent the immediate enlargement of the drift with perfect safety, provided proper precautions were adopted, and the work were done at once. But that these precautions would render the cost of the tunnel, when completed, quite as great as that of a first class bridge, and that even then the accommodation to the traffic would certainly not be as great as that afforded by a bridge.

Subsequently, at the request of the Government of the Punjab, I examined with some care the range of hills near Futtyjung, extending southward from Cheerat, and in which petroleum had been obtained. I saw everything to lead to the conclusion that petroleum would be found over a large area in these orbitolite limestone rocks, although probably not in any very great quantities in one place. The best position for trials seemed fairly indicated, and these I noted. The probability would seem to be that limited reservoirs of this oil will be found at no great depth from the surface, although I am not very sanguine that they will prove very extensive in any one locality. Similar rocks occur again in a rudely parallel range to the east, and here also traces of earth-oil are seen; and it would appear very probable that supplies will be found extending over a large area in this part of the Punjab.

An examination of the Dhurmsala district, and also of the Goorgaon district near Delhi, was requested, with a view to determine the extent of deposits of kaolin said to occur in each. Looking, however, to the inaccessibility of both and their distance from any markets, which must prevent the economizing of this clay to any large extent; and also to the fact that, so far as any local demand existed, it was of no importance to determine at the present the *extent* of these deposits, their existence being known, I felt compelled to think this enquiry was of vastly less importance than others. And that, so far as any question of extent or amount of such deposits was concerned, a very much more satisfactory answer could be given after the whole districts had been gone over than after a rapid visit to one or two isolated localities. No mistake can be greater than to imagine that a geologist can, by a sort of intuition, arrive at a knowledge of facts bearing on such questions. This can only be acquired by a continuous and detailed investigation necessarily demanding time.

BENGAL AND UPPER PROVINCES.—During the early part of the year just closed, Mr. Medlicott was engaged in the investigation of the western and southern flanks of the Garo Hills. So long since as 1842, Mr. Bedford, who had surveyed parts of this area, announced the occurrence of coal in the hills bordering the Bramahpootra River at the western extremity of the Garo Hills, near to a village called Harigaon, and other outcrops had been noticed further to the east in the Sumesurri River. The peculiarly favorable situation of these places, within easy reach of a great river, and in districts where fuel was otherwise not readily procurable, rendered it of high importance that the facts should be ascertained. It was also known that the rocks which accompany coal in the Khasia Hills extended to the west, and there was, therefore, a probability that the coal might also be found to extend in the same direction. It had long been hoped that a topographical survey of these hills would afford the means of recording carefully the geological observations, but as there appeared little likelihood of these hopes being realized within any reasonable time, and as meanwhile the question of the eastern and northern extension of the Eastern Bengal Railway was urgent, it was determined to examine the area, in such a general way as might be sufficient, without entering into minute detail, to solve the question satisfactorily of the probable amount and character of the coal which occurred there. Mr. Medlicott's report on the results of his examination having been published (*Records of the Geological Survey of India*, Part 1,1868, p. 11), it is unnecessary to enter into any detail here. It will be sufficient to state that he has shown that the spurious coal of the Garo Hills is geologically distinct from most of that known in the Khasia Hills; that, in all cases, this coal occurs near to the base of the whole stratified series within a few yards of the underlying crystalline rocks; while the coal itself is very poor, in one place mainly a resinous shale, in another, a thick bed of dark stiff clay with insignificant strings of lignite through it. Where in greatest quantity, it is described as a thick band of shale in the midst of which

occurs the coal-seam: it is a good deal crushed, altogether about three feet thick, but very unequally carbonaceous, being locally split by strings of clay and sand; and contains but few thin strings of coaly substance. The mass of what would be extracted as coal is a highly resinous batt or shale, full of small nests and strings of a kind of amber; it gives a woody sound when struck, is very tough, and breaks with a large conchoidal fracture. It was obvious that whatever little use might be made of such deposits, if required on the spot, they were practically of no value as a source of fuel for general purposes. It is most seriously to be regretted that the statements upon which expectations of coal had been founded should have proved to be so fallacious.

Having completed the cursory examination of these rocks, Mr. Medlicott devoted some time to a more careful examination of the Khasia Hills, for which portions of the topographical survey maps were ready. These very interesting hills had never before been visited by any of the officers of the survey at a time when it was possible to examine the lower parts of their steep slopes; and consequently, as pointed out long since, much remained to be done, before we could suppose that we possessed any true knowledge of their structure. Further, the full determination of the cretaceous age of the sandstones, &c., under Cherra Poonjee, *(Quar. Jour. Geol. Soc. London*, 1863, p. 524, Oldham, on cretaceous rocks in E. Bengal) which, in my own early description, in consequence of their apparent continuity and conformity, (the fossils collected having been lost at sea) had been grouped with the tertiary rocks above, rendered it necessary to carry out this separation in detail. Mr. Medlicott has been able to do much towards this, and in tracing out these rocks has been led to several very valuable conclusions, a brief summary of which has already appeared in the Records of the Survey. As soon as the topographical survey of these hills is completed, I hope to be able to have them examined in detail.

Later in the season, Mr. Medlicott having arranged for the several duties assigned to the assistants under his charge, was requested to take up the very important geological question of the extent and relations of the several series of sandstones, &c., associated in Bengal with the coal, as compared with those in Central India. With this object, making a rapid traverse of the Ranigunj field, and passing westwardly by the Hazareebagh fields, he has carried out the section across to Jubbulpore, and with very valuable results, which will tend much to a clearer understanding of the different groups or formations. In a new country, where the general relations of the rocks is quite unknown, it becomes necessary for each observer to form for himself a classification of the rocks he examines, grouping them into series or formations, and often giving to these sub-divisions local names. But as the examination of the country advances, it not unfrequently happens that such classification is proved to be of purely local type, and it is essential either to increase the sub-divisions or to bring several together into one larger group. Mr. Medlicott's traverse of this wide extent of country will go far, I believe, to remove, in several cases, the limited amount of confusion which had unavoidably arisen from the fact that previously the officers of the survey had been working at distant and isolated points.

Mr. Willson has completed the detailed examination of the district of Saugor in the Central Provinces, which he has connected with those of Dumoh and Jubbulpur to the east. Unfortunately the want of maps of the country lying to the west of Saugor district has prevented the extension of our examinations in that direction, as I was very desirous of doing, in order to join on the geological lines to those we have been for some time past steadily carrying southwards through the Gwalior and Rajpootana territories. The district of Saugor is mainly composed of trappean rocks, which are, in this parallel, the most northerly portion of the Great Deccan area of these ancient volcanic rocks. These rest upon Vindhyan rocks for the greater portion of their boundary.

Mr. Mallet has, during the early part of the year, completed the examination of the crystalline rocks of Bundlecund—being a continuation of his work of the previous year—so far as the area occupied by these rocks is comprised on sheet 70 of the Indian Atlas. The further explorations of this year have rather induced Mr. Mallet to abandon the idea of separating these rocks into two series as was suggested in 1866-67. The evidence, however, is even yet scanty, and not conclusive. And it must remain for more careful investigation when better maps, on a larger scale, of the Bijawur area become available. The maps, at present procurable, are too imperfect to admit of any close or searching examination and record.

During the recess, Mr. Mallet completed a full report on the Vindhyan rocks, so far as that widely spread formation is known in northern India up to the present. A general map has been compiled to illustrate this. This report has been sent to press. At the commencement of the working season in October 1868, Mr. Mallet proceeded to take up the detailed examination of the eastern part of the Sone Valley, and is still engaged in that area. I have already intimated to Mr. Mallet the necessity for greater activity in the field, for looking both to the nature of the work done, and of the country in which he was engaged I felt disappointed that a larger area had not been satisfactorily examined.

Carrying on the geological examination of the Gwalior and adjoining territories, Mr. Hackett was principally engaged near to the Byana hills bordering on Jeypur. The geology of this area has proved intricate and interesting. The sections are unfortunately not good, being cut up by intervening flats of alluvium which conceal the rocks. Rock masses of a peculiar character have been found to intervene between the Vindhyan series, and the metamorphic schists, which may approximately be taken to represent the Lower Vindhyan and the Gwalior series. These are possibly the same rocks as those which stretch away towards Ulwur, and if so, this will give a clue to the geology of the Aravali country. The country around Byana is, as I have already said, rather intricate in structure, and tedious therefore to work out, but I am not satisfied that a larger area might not have been completed during the season. Towards the close of the year, Mr. Hackett resumed his labours in the same or the adjoining country, but has been stopped by a want of maps. He has since been engaged further to the south in tracing out the boundary of the Vindhyan and trappean rocks to the east of the parallel of Neemuch, &c.

Mr. Hughes in the early part of the year was engaged in re-mapping the small coal-fields which occur detached near Kuroun in the district of Beerbhoom, and in revising with better maps, the Kurhurbaree coal-field. It has been difficult to obtain any very satisfactory information regarding this field, for the old pits which were some years since worked by the East Indian Railway Company are now full of water, and there are few other workings in operation. Any description, therefore, now given must be revised when the field is more opened out. At the close of the year, Mr. Hughes was engaged in the examination of the Palamow coal-field in Chota Nagpore. This might, Mr. Hughes thinks, be called in preference the Daltongunj field. It proves very small in area, not more than about 30 square miles, and there appear to be only two seams which can be worked, of which only one could at present be profitably extracted. This varies considerably in thickness. At Rajbera, where it was formerly worked by the Bengal Coal Company, it is eleven feet. It is of moderately good quality. The rocks of the field belong entirely to the Talcheer and the Barakar groups. The lithological character of the latter differs considerably from that of the typical rocks in the Ranigunj field, being as it were intermediate between the Barakar and the Ranigunj groups.

Mr. Ball has been carrying on the geological examination of the districts of Singhbhum and adjoining tributary states. He has been able to examine the copper-yielding rocks for a distance of nearly 80 miles; has noted some additional details with reference to the mode of occurrence of gold; and describes cases of excessive local metamorphism of the younger rocks, reducing them to such a crystalline condition as to be entirely undistinguishable lithologically from the old metamorphic rocks. Such cases are deserving of very careful examination.

Mr. Ormsby had, in the early part of the year, examined a considerable area of the metamorphic rocks in Chota Nagpore and Hazareebagh, but was unfortunately obliged to leave for Europe in consequence of ill-health before the close of the season.

Having very frequently had occasion to represent the importance of deputing a special officer of the Survey to the examination of the mines of India, and to the careful collection of statistics regarding the quantity and value of minerals raised and brought to market, I was glad to find that a gentleman, selected for this purpose, had been ordered to join the department at the beginning of the year. Mr. Mark Fryar, thus nominated as Mining Geologist in connection with the Geological Survey of India, joined his appointment in this country on the 1st of May 1868. After a little time in Calcutta, Mr. Fryar was deputed to the Ranigunj coal-field, there to make himself acquainted with the coal-bearing rocks of India, and the method of mining adopted in this, the most valuable, coal-field in India. It was necessary that he should acquire a knowledge of the rocks as locally developed, which would be useful in other localities, and indeed perfectly essential before he could safely take

up any enquiry in a new and undeveloped district. Mr. Fryar also, later in the season, visited the Kurhurbaree coal-field, when Mr. Theo. Hughes pointed out to him the several groups and their characteristic lithological characters. Towards the close of the year Mr. Fryar was deputed to the Nerbudda valley, and to pass thence southward by Chindwarra to Nagpore and Chanda, where Government had sanctioned the full and detailed examination by actual sinkings and borings of the extent and character of the coal known to exist there. For this purpose boring rods of best construction and borers have been despatched from England, and the work will be taken in hands at as early a date as possible. Mr. Fryar has submitted brief reports on the coal found at Lameta Ghât, Jubbulpore, and on the workings at the Nerbudda Coal and Iron Co.'s colliery at Mopani. The localities must again be visited by some one knowing the Indian rocks.

I hope that the necessary appliances for boring, &c., which have been sent for, will reach this country before it be too late to do any thing this working season. Once commenced, the investigations will be carried on systematically, so as to ascertain exactly the full extent of area over which the coal beds extend and the thickness and nature of the coal itself. The country is much covered with alluvial deposits, and excepting by actual trials it will be impossible to say what the extent of the coal-fields may be, while the importance of the locality taken in connection with the supply of fuel on the Nagpore branch of the Great Indian Peninsula Railway and for other purposes, cannot be over-estimated.

It has not been found possible, with the reduced number of our staff, during the present season to place any one of the officers of the survey in this part of the country, with a view to trace out the extension of the coal-bearing rocks to the south from Chanda, if they do so extend. It is probable that the further extension will be traced, although the evidence seems tolerably conclusive that there is a continuous diminution in thickness of these rocks as they pass to the south; and it is highly probable that they will be found not to extend much further than they have been already traced. We know that they have entirely disappeared, at about seventy miles in that direction, and steps will be taken at the earliest possible date to have the intermediate country examined. Reports of the occurrence of coal have frequently been circulated, and recently it is stated to be in some quantity near Domagoodium: but these reports have not as yet been confirmed.

When proceeding to the Ranigunj field, I specially directed Mr. Fryar's attention to the very high importance of inducing, if possible, the colliery proprietors to economize the large amount of waste and dust coal which at present is allowed to take fire and burn away to no useful purpose at the pits. The peculiar structure of Indian coal renders the proportion of this waste, produced in hewing, larger than in coal of a more homogeneous and richer character, while the very much greater brittleness of the strings of rich jetty coal as compared with that of the tougher laminæ of earthy matter also adds to the proportion of the better fuel, which is lost in the waste. I urged on Mr. Fryar to induce some of the proprietors to make trial of washing and compressing this waste and dust so as to form bricks or cakes of fuel, and mentioned to him the success which had attended some experiments made by myself, on the use of common rice water as a medium for agglutinating the mass. Several trials were made and many bricks produced from washed waste, and, as I believe, good promise of success was established. The system has not, however, as yet recommended itself to the proprietors; they believe that the expense and cost would not be repaid by the result, and they have therefore not taken any steps to carry the trials further.

In the experiments I had myself made years since, and in those which were made by Mr. Fryar during the past year, no sufficient pressure was available. And in consequence, although the rice-water appeared to act very successfully, there was much too large a quantity of it taken up. The result of this was the comparatively open and uncompressed texture of the bricks, and when put on the fire they smouldered away rather than burnt. The only pressure used was that of a very inferior brick machine, nor was anything like proper attention paid to washing the dust before moulding.

I am quite confident that a very large amount of most valuable fuel could be with profit economized in this field, all, or almost all, of which is at present allowed entirely to go to waste. I do not anticipate that it will ever be profitable, under the peculiar circumstances of Indian fields, to adopt the suggestions thrown out by some who have never seen these fields, of reducing all the coal extracted to fine powder by crushing, then washing, moulding

and baking into symmetrical blocks. But I am satisfied that much may be made out of the dust and dead-small coal, now wasted. The peculiar conditions of the field render it compulsory that all this should be brought to bank so that the only expenses to be incurred are in the actual manufacture. It would surely be more profitable to reduce a larger portion of this waste into the state of good useful fuel than to allow it to take fire and burn itself to a heap of ashes.

Mr. Fryar's attention was also given to the utilization of the small coal and dust for the production of coke, and with considerable success.

During the past year, a circular was addressed to the proprietors of collieries from this office, urging on their consideration the vast importance of maintaining proper under-ground plans, pointing out very briefly the advantages to be derived from such. And I was much gratified to find from the replies received from every one of the large proprietors that they not only saw the advantages to be gained, but were determined to secure them. Careful plans are now being made of most of the mines in the Raniguni field; plans of the workings in the Kurhurbaree field will be commenced as soon as the workings there commence under the East Indian Railway Company, and will be maintained. In the Nerbudda plans are kept. I look upon this as a most gratifying progress for a year or two. The largest coal proprietors in the Ranigunj field have not only engaged a qualified mining surveyor, but they have ordered all their assistants to pass an examination in the use of the surveying compass, &c., and have secured attention to this study by giving an increase of Rs. 50 per month to the salaries of those who may pass. The same Company has also given an excellent example of progress by ordering one of their own servants, and who, by their permission only, is also examiner of steam-ship boilers under the Government of Bengal (Mr. Walker), to proceed each half-year to their works to examine carefully and report upon, in detail, the condition, work, duty, and capabilities of every one of their steam engines; this report to be submitted previously to each half-yearly meeting of the Company.

MADRAS.—In Madras Presidency, Mr. Foote was absent on medical certificate during the greater part of the year. He only returned late in October. The remainder of the party, Mr. C. Oldham and Mr. King, commenced the season's work north of Ghooty, and marching up to Kurnool, surveyed, as they passed along, a sufficient breadth of country outside of the boundary line of the Kuddapah rocks, to ascertain the non-existence of any outliers of those rocks in that neighbourhood, and to obtain a good general idea of the character of that area of metamorphic rocks. It proved to be chiefly an area of granitoid gneiss, with a few trap-dykes, and some runs of fault-breccia; the prevalent directions of these being west-north-west, with variation to north-west, and east-north-east, with a variation to north-east.

From Kurnool, the Surveyors passed across the hills to the east, by the Muntaval pass. Mr. King separated from Mr. Oldham at Doopaud, from which he moved northwards, carrying on his examination in connection with the survey of the previous season. Mr. Oldham proceeded to the Kistna district to join the Superintendent.

Mr. King rejoined Mr. Oldham in the middle of February, and working first through the Vinuconda taluq, they then passed into the Palnad, and carried their geological lines up to the Kistna River. Parts of this country are very difficult of access, wide areas quite uninhabited, without roads and without any means of obtaining needful supplies. Much of the geological structure is also intricate, and the district is at the same time very unhealthy. The temperature during the past year was unusually high in April and May, and repeated attacks of fever prevented the officers of the survey from carrying on their examination with their usual vigour. They continued, however, at work until the beginning of June, when Mr. King was compelled to proceed to station. Mr. Oldham went northwards and crossed the Kistna, hoping to be able to complete a detailed survey of the Juggiapett country. A part of this only could be accomplished, for the early and heavy break of the monsoon compelled him also to leave the field about the middle of June.

During the autumn Mr. Oldham delivered at the Civil Engineering College in Madras a course of lectures on Geology. These were attended, and with marked regularity, by a larger number of the general public than on previous occasions, while the engineering class was also very attentive and interested in the subject.

When I left the neighbourhood of Juggiapett early in the year, as already referred to, I had hoped that there would have been time to accomplish a detailed survey of that small area, taken in connexion with the adjoining country, before the close of the season. As I have just stated, the early and very severe setting in of the monsoon prevented this. I regret this the more, from the reiterated statements which have been made as to the existence of coal in that vicinity. Mr. C. Oldham, in regretting that he was compelled to give up the attempt to finish the work at that time, says—'I was, however, able to trace out the succession of the beds there for a considerable distance, and I had the opportunity of examining with somewhat more detail than we were able to do, during our visit early in the year, the way in which the rocks lie, and to convince myself (in entire accordance with your own conclusions) that, certainly over the part of the area which I was able to survey, in which are some of the localities where coal had been reported, not only does none appear, but that the occurrence of any thing like a workable seam of coal, unseen, is impossible. The rocks are singularly well exposed and their succession very clearly seen. The general succession of rocks seen in the Juggiapett area is, in ascending order, quartzite slate, limestone, schistose slates, and over these upper slates, in the hills to the south, comes apparently another set of quartzites.' The two lower groups, Mr. C. Oldham is inclined to refer to the Kuddapah series of rocks; and the limestone with the slates above it to the newer Kurnool group. There is apparently unconformity between the two series here, as in many other places. The Kurnool rocks cover a large area in the Palnad, and the two limestones with associated shales, are seen separated by quartzite, (the 'Pancum' quartzite of the survey); this is locally of considerable thickness and forms a very well marked bed, but elsewhere it thins out to a couple of feet or even disappears altogether. The lower limestone of the Palnad is apparently identical with that which covers so very large an area near Juggiapett, although the actual continuity of the two still remains to be traced. Much of the limestone would form a very durable and excellent building material, and several of the beds would yield a handsome ornamental marble, being veined in different colours, chiefly buff and pink.

Chipped stone implements were traced up to the Kistna district. On the Muntaval pass, one was extracted from hard solid laterite.

From Bezwara, Mr. C. Oldham visited a small area of sandstone at Tunglamoody, about 14 miles south-south-east of Bezwara. These sandstones there form a rising ground or hillock of no great extent. They are quarried for use in the adjacent country, where many temples have been built of them. No fossils were traceable, but from the general character of the rocks, Mr. Oldham considers them as belonging to the same group as the plant sandstones further to the south, to some of which they bear a great resemblance. Further, while marching back to Madras from Guntoor, he noticed similar sandstones and some porcellanic shales in several places near to Yinkolu, and south of that along the road: and at Razpoody a considerable amount of them is exposed, chiefly a greyish and yellowish shaly sandstone. These beds are quarried to some extent for local building purposes. The great resemblance lithologically of these rocks (shaly sandstones, and porcelain-like shales) to those in the neighbourhood of Sripermatoor, in the Madras district, is striking. Mr. C. Oldham thinks all these belong to the same series, and thus we have, at a distance of 450 miles from where we first found them in the Trichinopoly district, remains of a series of deposits once continuous, and the connection of which is now only indicated by the many detached areas of the same beds, which have been traced by the survey in the South Arcot, North Arcot, Madras, and Nellore districts.

BOMBAY.—The Bombay party of the survey has been during the whole year under the charge of Mr. A. B. Wynne, Mr. Blanford being, during all the time, absent with the Abyssinian Field-force. The party was engaged in the examination of Cutch, of which area about one-half has been very carefully completed. The reported occurrence of coal, said to be in workable quantity, was one reason which demanded a careful investigation of the rocks and their relations. But the principal interest connected with the investigation of Cutch centered in the fossils, which occur there in considerable abundance. Along with others, very well preserved remains of peculiar plants occurred, easily recognizable, and giving a very marked *facies* to the flora of these rocks. This was characterized by the predominance of various forms of Cycadeæ. These same forms of Cycadeæ had been found in abundance in Bengal, at the opposite side of the Indian peninsula, and in many places near to Madras, far to the south. In the Rajmahal Hills no associated beds occur from which the true geological horizon

of these plant-bearing rocks could be made out, while in Madras presidency also, although the succession clearly established that these rocks were not younger than the cretaceous formation there developed, there was (equally as in Bengal) no possibility of fixing their lower limit in geological time. In Cutch these plant-bearing beds, on the contrary, were said to occur associated with rocks rich in marine fossils, well preserved, and the geological epoch of which was well marked and readily determinable. But although undoubtedly associated with the marine fossiliferous beds, the mode of this association was still uncertain. Captain Grant, the original describer of the province, left it doubtful; while Mr. W. Blanford, during a cursory visit to part of Cutch, was led to believe that the plant-bearing rocks were actually intercalated with the others. The facts, as resulting from Mr. Wynne's very careful and detailed examination, appear to be that a very few and very imperfect remains of plants do occur in layers distinctly intercalated with the truly marine beds, and have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilized in these beds, then existed. But as a whole the beds in which the well-marked *Palæozamiæ* occur are decidedly younger than those containing the truly Jurassic *Ammonites* and other characteristic fossils; and that they constitute an upper zone, but belonging to the Jurassic period. These very important results will be illustrated in detail in Mr. Wynne's reports.

Mr. Fedden has been engaged with Mr. Wynne in this careful examination of Cutch, and has more especially devoted himself to the portion of the province occupied by the tertiary rocks.

Very extensive and valuable collections of fossils have been made by this party of the survey, and transmitted to the Museum.

BURMAH.—Mr. W. Theobald, Junr., having returned from absence of leave, resumed the examination of British Burmah towards the close of the year. The time which elapsed up to the end of the year has been too brief to admit of any great progress. The country under examination has been that portion of the Prome district which stretches between the Eastern or Pegu Yoma and the Irrawaddi, and lies to the north of the Toung Raweng stream. This will, when finished, complete the whole of the Prome district east of the Irrawaddi. I confidently hope that we shall now be able to complete the examination of all British Burmah soon. The results at best are unsatisfactory from the absence of any good sections; and any attempt at classification of the rocks can only be of the largest kind. The whole country is too much covered to admit of any great detail.

PUBLICATIONS.—During the year under report, we have commenced the issue at stated intervals of a new series of publications called the "RECORDS OF THE GEOLOGICAL SURVEY OF INDIA." These are printed in smaller type and on thinner paper (for free transmission by post) than the more detailed Memoirs, but of the same size, so that they can on completion of a volume be bound with these. It is contemplated to issue a number every three months, making four numbers or parts in the year. It was impossible, however, to commence the issue until after several months of last year had passed, and therefore, for 1868, only three numbers appeared. In explanation of the object with which this series has been commenced, I may quote here from the brief Prefatory Notice which accompanied the first part. 'This series will contain a notice of the current work of the survey up to date; a list of contributions to the Museum or Library; a list, and occasionally an analysis, of such books published elsewhere, as bear upon Indian Geology; and, generally, of all facts illustrating the immediate object of our researches, which may from time to time come to our knowledge.'

The three numbers issued in 1868 have contained papers on very varied subjects; coal, gold, copper, fossils, and several local descriptive papers, which have proved of much interest to local officers; also lists of all additions to Library, &c., during the year.

I am happy to say this new series of publications, although necessarily issued with very few illustrations, has already attracted much interest, and I think will prove very useful.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA, a very valuable part has been issued, containing a full report on the geology of the lower parts of the Nerbudda and Taptee Valleys by Mr. W. T. Blanford. The delay involved in the preparation of the necessary illustrations for this paper caused it to appear later than I had hoped. In the same part is also a detailed description of the structure and anatomy of the very curious little frogs long

known to be found in some thin papery shales near Bombay. To these Professor Owen had in 1847 given the name of *Rana pusilla*. More careful investigation, and more perfect specimens, show that these strange little frogs belonged to the existing genus *Oxyglossus*.

Mr. Blanford's report includes all the country lying between the parts already described by Mr. J. G. Medlicott (see Vol. II, *Memoirs Geol. Survey of India)* and the Gulf of Cambay, and thus completes a geological section right across the peninsula to the neighbourhood of Bombay.

This part completes Volume VI of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

Of the figures and descriptions of Indian fossils, included in the Palæontologia Indica, the second half of the description of the Cretaceous Gastropoda was issued in October. This contained four fasciculi, and being ready at that time, I was enabled to issue it in advance, so as to carry the publication up to October of the present year. The danger of loss, the facility of destruction or injury, and the delay in transmission, of the smaller fasciculi, render it preferable to issue the whole series due for a year at once, if this be ready.

The description of the Gastropoda, concluded in these parts, was carried out to the close with the full detail to which I specially alluded in my last report.

Much progress has been made in the preparation of the needful plates for the illustration of the Bivalves, the group which will be published next.

At the request of several local officers we have, during the year, furnished brief geological descriptions of their districts, which they needed for statistical accounts, descriptive reports, &c., &c.

LIBRARY.—During the twelve months of 1868, we have added to our library 1,766 volumes, or parts of volumes, of books. Of this total 508 were presented or received in exchange for the publications of the Geological Survey from Societies and other institutions. We continue to maintain our catalogue of these books up to date, and in the new series of our quarterly publications (THE RECORDS) a complete list is given, in each part, of those received during the preceding three months. It is hoped that this announcement being sent to the several Societies from whom the presentations have been received will suffice as an acknowledgment, and will thus obviate the necessity of separate communications.

We are quite as seriously inconvenienced in our Library arrangements, by the want of sufficient space, as in the Museum. The books are necessarily placed in double rows and often far too crowded in their cases. This renders it impracticable to be as careful of them as might be, and also seriously interferes with facility of consultation or reference. To give fair room for all we would require at least double the number of cases and shelves we have at command.

To this report is appended as usual a list of the Societies and Public Institutions from which the Geological Survey of India has received donations or exchange of publications during the year 1868.

In my last report I stated that the literature of Geology, Mineralogy, Palæontology, &c., had of late years so vastly increased that it was impossible to maintain our library effectively from the small sum annually appropriated to such purposes and I am happy to be able to state that an increase to this sum has since then been sanctioned.

MUSEUM.—Up to the close of the year we had not received all the series of fossils procured during 1867 in Europe, in connection with the purchase of the Klipstein collection. But few now remain to be received, and I hope to be in possession of all at an early date.

During the year, I had the advantage of the aid of Mr. Geoff. Nevill in arranging, preparing, and cataloguing these fossils as opportunity offered for opening and examining them. In many cases, the want of space has rendered it necessary merely to open, examine, check, and pack up again, box after box, as we have not space in which even to arrange, much less exhibit, our collections. Three additional rooms have been given up to the museum, and this will afford a certain amount of relief, when we have been able to procure cases. During the year more than 6,000 specimens have been catalogued.

We have returned to the Central Museum, Madras, the Cretaceous Gastropoda which they had been good enough to lend us for examination and description, and we have added to the

list as complete a series of duplicates of this group of fossils as our collections could afford. I think local museums should especially, and in preference to any more general illustrations, seek to render their collections specially rich and illustrative of local Natural History, and my desire has been to place in the Madras Museum the best series of duplicates which could be selected from the very interesting and valuable collections of Trichinopoly fossils made during our geological examination of that district in the Madras Presidency. With a similar object, I also sent to the Museum at Rajamundry as complete a series as our collections would afford of the interesting tertiary fossils found close to that town, carefully named, and with accurate references; so that those interested might have some good data for comparison, if they had the opportunity of adding to these local collections. We have also during the year examined and named for several persons specimens and small collections.

From the officers of the survey working in Cutch, the collections have received very large additions; among which are many good specimens. The other parties of the survey have not been engaged in richly fossiliferous districts. Mr. Medlicott has brought a small series from the Khasia Hills, and a few have been received from Burmah.

METEORITES.—To the noble collection of meteorites in our Museum have been added during 1868 specimens of the fall of Pultusk, 30th January, 1868: of Klein Menow, 7th of October, 1861: of Perth, 17th May, 1830; of Ornans (Doubs), 11th July, 1868; and of Lodran near Mooltan, 17th of October, 1868, being five in all. Of one of these (Klein Menow) our collection contained a minute fragment before, but we have now obtained a very splendid specimen. The others are all new to our series. For the very rare specimen from Perth, I am indebted to the friendly kindness of Mr. Wm. Nevill, Godalming, Surrey, from whom also I procured the Klein Menow specimen. To my good friend M. Jules Marcou, Paris, I owe the specimen of Ornans, while the contribution of that from Pultusk was among the latest communications received from the able Director of the Imperial Mineral Cabinet at Vienna, Dr. M. Hörnes, since deceased. This was only one among a very numerous and long-continued series of friendly communications, in which I have ever experienced the most hearty and graciously rendered support and co-operation from the Austrian Geologists, and from none more warmly than from the greatly regretted Hörnes.

A small map is as usual appended, showing roughly the areas of which the geological examination has been completed, or is now in progress, in connection with the survey.

THOMAS OLDHAM,

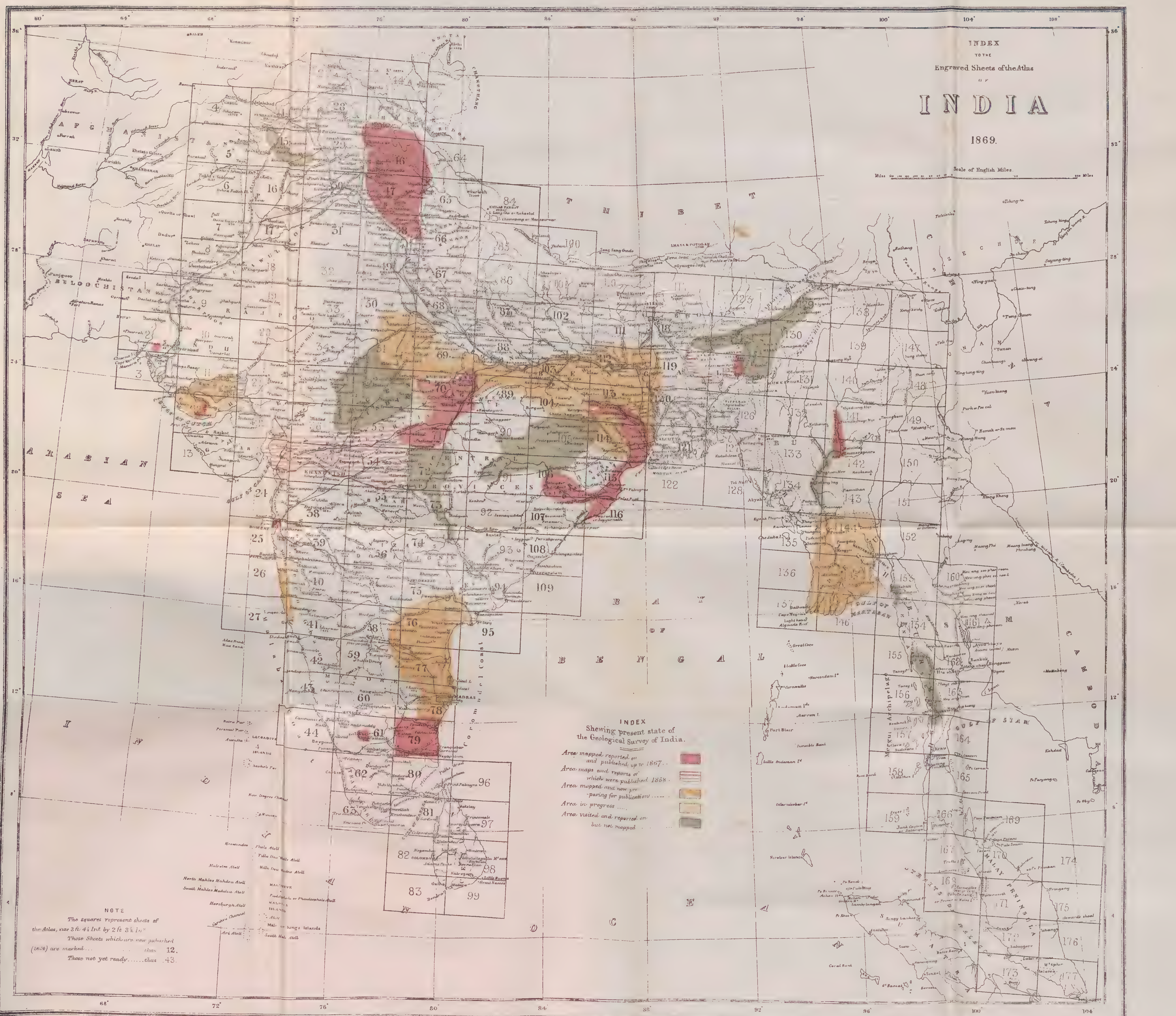
Supdt. of Geological Survey of India, and

Director of Geological Museum, Calcutta.

GEOL. SURVEY OFFICE;
CALCUTTA, *March* 1869.

List of Societies and other Public Institutions, &c., from which Publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1868.

LONDON.—Royal Society.
" Royal Institution.
" Royal Asiatic Society.
" Geological Society.
" Geological Survey of Great Britain and Ireland.
" Royal School of Mines.
" Royal Society of Arts.
" Royal Geographical Society.



Reduced and Photolithographed from "Hand Map of India," at the Surveyor General's Office, Calcutta, April 1869.

DUBLIN.—Royal Society.
„ Royal Geological Society.
EDINBURGH.—Royal Society.
GLASGOW.—Geological Society.
CORNWALL.—Royal Geological Society.
VIENNA.—Kais. Hof Mineralien Kabinet.
K. K. Geologischen Reichs-Anstalt.
Kais. Akad. der Wissenschaften.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
BERLIN.—Deutschen Geologischen Gesellschaft.
BRESLAU.—Schlesischen Gesellschaft für Vaterland. Kultur.
MUNICH.—Kön. Bayerischen Akad. der Wissensh.
MOSCOW.—Société Impériale des Naturalistes.
SWEDEN.—Bureau de la recherche Géologique.
NORWAY.—Royal University of Christiania.
PARIS.—Comm. des Annales des Mines.
„ Société Géologique de France.
DIJON.—Acad. des Sciences.
CAEN.—Société Linnéenne de Normandie.
BELGIUM.—Academie Royale des Sciences, Bruxelles.
NEUCHATEL.—Société des Sciences Naturellés.
LAUSANNE.—Société Vaudoise des Sciences Naturellés.
ZURICH.—Naturforschenden Gesellschaft.
TURIN.—Royal Academy.
GOETTINGEN.—Königl. Gesellschaft Wissenschaften.
GERMANY.—Leop. Carolino Acad. of Sciences.
COPENHAGEN.—Danish Academy.
PHILADELPHIA.—Franklin Institute.
„ American Philosophical Society.
„ Academy of Natural Sciences.
BOSTON.—Society of Natural History.
AMHERST, MASS.—Museum of Compar. Zoology.
SALEM.—Essex Institute.
WASHINGTON.—Smithsonian Institute.
NEW HAVEN.—Connecticut Acad. of Arts and Sciences.
TORONTO.—Canadian Institute.
VICTORIA.—Geological Survey.
„ Office of Mines.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Indian Annals of Medical Science.
BOMBAY.—Branch of Royal Asiatic Society.
ROORKEE.—Thomason College of Civil Engineering.
Governments of India, Madras, Bombay, Bengal, North-Western Provinces, Chief Commrs., Oude, Central Provinces, Burmah.
Great Trigonometrical Survey of India.

NOTE *on* PANGSHURA TECTA, *and two other species of* CHELONIA, *from the newer tertiary deposits of the Nerbudda Valley,* by FERD. STOLICZKA, PH. D., *Palæontologist, Geol. Surv. of India.*

While engaged in the examination of the tertiary (? pleiocene) deposits of the valley of the Nerbudda river in 1858, Mr. W. Theobald, Junior, obtained, among other fossils, a few remains of CHELONIA which are of great interest as throwing light upon the then existing representatives of this reptilian order.

Mr. Theobald described these deposits at some length in a paper "On the tertiary and alluvial deposits of the central portion of the Nerbudda valley" (Memoirs, Geol. Surv., India, Vol. II, p. 279). He distinguishes two groups of beds, an upper and a lower. To both of these a large number of the fossils is common, but Mr. Theobald is inclined to think that those of the upper group may have been, partially at least, derived from the denudation of the lower group. The beds of this lower group are more fossiliferous than the others, but they can only be examined where they are exposed in the banks of the Nerbudda river itself, and in those of a few of the larger tributaries. The same author also gives a list of land and fresh-water shells found in these beds. Many of the species noted are still met with recent, and some appear to be identical with those determined by Prof. Ed. Forbes from the Sevalik strata (see Falconer's Palæont. Mem., Vol. I, p. 389). Of the vertebrate fossils also, several species are common to both the Nerbudda and Sevalik strata. Still some peculiarities in the Bovine and Pachyderm types have been pointed out, which seem to show that the deposits of the Nerbudda valley are younger than those of the Sevalik hills. On this point it is difficult to arrive at any definite conclusion from the examination of the fossils alone. The comparatively larger number of Bovines in the Nerbudda beds, as contrasted with the Pachyderms, the absence of Mastodons, &c., may be due to local causes. And further, the number of fossils as yet known from the Nerbudda is small, while from the Sevaliks, which have been examined more in detail, we have a large number of well determined species. The only question is, whether all the fossils which have been described from the Sevaliks really belong to one series of beds only, or whether they do not in reality represent somewhat distinct horizons (the Nahun series, the upper and lower Sevaliks, &c.) It is certain that no particular attention was paid to these divisions when the earlier collections were made. Much is therefore still left to be worked out, both in the Nerbudda and in the Sub-Himalayan country.

In the present note I shall direct attention only to the Chelonian remains from the Nerbudda valley. Mr. W. Theobald, in his report quoted above, repeatedly states that Chelonian remains occur throughout the lower group, but that they are rare as compared with those of the Mammalia (see pp. 289, 290, 292). Besides these remains of Chelonia I am not aware that any other reptilian remains have been met with in the Nerbudda beds, although Saurians and others most probably existed within that area, as they do now, and as they did already during the time, and in the area, of the Sevalik deposits.

These Chelonian remains are referrible to three species; one, which is sufficiently preserved, has been identified with the recent *Pangshura tecta*, and, of the three other fragments, one appears to belong to a recent *Batagur*, and the other two to a *Trionyx*.

I shall give first a short description of these remains, and then add a few words respecting the conclusions resulting from this examination.

PANGSHURA TECTA, *Bell*, sp., Plate I, Figs. 1, 2.

Emys tectum, Bell, Monog. Testudinarum.
 „ *tecta*, Gray, Illustrations of Indian Zoology.
 „ *Namadicus*, Theobald, 1860, Mem. Geol. Surv., India, Vol. II, p. 295.
Pangshura tecta, Günther, 1864, Reptiles of India, p. 33.
Emys tecta, Falconer's Pal. Memoirs, 1868, Vol. I, p. 388.

The shell of *Pangshura tecta** has an elongated oval form. The centre of the back is elevated, more or less distinctly carinate, the sides are rather flattened and slope at an angle of about 45°, which increase up to 50° towards both ends. The carapace is anteriorly

* I have adopted here the change in the specific name, *tecta*, as being more in accordance with the general system of nomenclature, although Bell said that Gray had misquoted the name *tecta* instead of *tectum*, the roof of a house, which was intended to express the general form.

about equal to, or a little shorter than, the sternum, and slightly emarginated; posteriorly it is obtusely rounded, and at the marginal shields more or less distinctly serrated.

In the specimen figured on Plate I,—which was discovered by Mr. W. Theobald at Moar Domar in the Nerbudda valley,—the carapace agrees in every respect with that of the recent species, as will be shown by giving the necessary details of its structure. To facilitate a careful comparison, I have also given a drawing of one-half of the dorsal and ventral views of the carapace of a small specimen, procured living in the neighbourhood of Calcutta. These drawings are intended to illustrate not only the epidermoid but also the osseous shields. Proper attention is seldom given to the latter in zoological works, although in palæontological researches they are of greater importance than the former.

The fossil figured is not perfect, the posterior portion of the carapace not having been found; but the rest of the shell is quite sufficiently preserved to admit of careful comparison for specific identification. The general form of this fossil is, as already stated, exactly the same as that of recent specimens.

Epidermoid plates.—The nuchal shield is very small, narrower anteriorly than posteriorly. All the five vertebrals are obtusely carinated in the middle, and the first three become successively more and more elevated at the posterior end. The first vertebral is pentagonal with an obtuse projecting angle in front, slightly emarginated at the sides, narrow and truncate behind. The second vertebral is about the same size as the first, also pentagonal, truncate at both ends, considerably narrower posteriorly than anteriorly, laterally, at one-third of the length from the front edge, widest and angular. The third vertebral is the smallest, but the highest of all, pentagonal, truncate in front, angular at the sides, after which considerably produced posteriorly, becoming gradually narrower and terminating with an obtuse point. The fourth vertebral is bell shaped, very much prolonged, joining the third with an obtuse point, then becoming gradually wider until it reaches about three-fifths of its length, after which it narrows again, terminating with a truncate side, about one-half of the greatest width of the shield. Of the fifth vertebral only the anterior portion is preserved, showing it to be truncate in front and quickly widening posteriorly. The sides were probably obtusely pointed and the posterior termination truncate, broader than the anterior, as in recent specimens. In these the sides of the fifth vertebral are sometimes pointed, sometimes distinctly truncated. Costal or lateral plates are five, all being transversally elongated and of a more or less irregular pentagonal shape. They entirely agree with those of living specimens, as is equally the case with the marginal shields, which are eleven in number on either side. The serration of the posterior marginal shields remains to be properly recorded if better preserved specimens should be discovered, for neither is it distinctly traceable in the figure given by Dr. Murchison in Falconer's Pal. Memoirs.

On the ventral side we have first to notice a pair of small, triangular, posteriorly pointed gular shields. To these follows a pair of larger, subquadrangular post-gulars; then a pair of rather high pectorals, next to which are the abdominals, being the largest, and then the other shields of normal size. The axillaries are comparatively small, posteriorly pointed, the inguinals large anteriorly, on the external side obliquely truncate. The longitudinal ridge which connects each axillary with its corresponding inguinal is very distinct, sharp and slightly longer than in most recent specimens. The plastrum is distinctly concave, probably a little more so than in male specimens, as usually met with about Calcutta.

Osseous plates.—The distribution of the osseous plates, as is well known, does not agree with that of the epidermoid shields. There is a very large nuchal plate and a very small caudal, the latter not being preserved in our specimen. There are ten small vertebrals, the last (the largest) not being seen in the fossil, but the other nine perfectly agree in their relative proportions and in their relations to the epidermoid shield with those of live specimens. The costal shields are eight; the first is the broadest, with reference to the longitudinal diameter of the carapace; all the others are very narrow. The number of marginals is eleven on each side.

On the plastrum we have a pair of subquadrangular gular shields, to which follows a pair of very large pectorals, these four shields enclosing in the middle a single, suboval post-gular; there is besides a pair of very large abdominals and one pair of smaller anals. The axials and inguinals are not separated from the pectorals and abdominals respectively.

No portions of the internal skeleton, as the extremities, &c., have been found preserved.

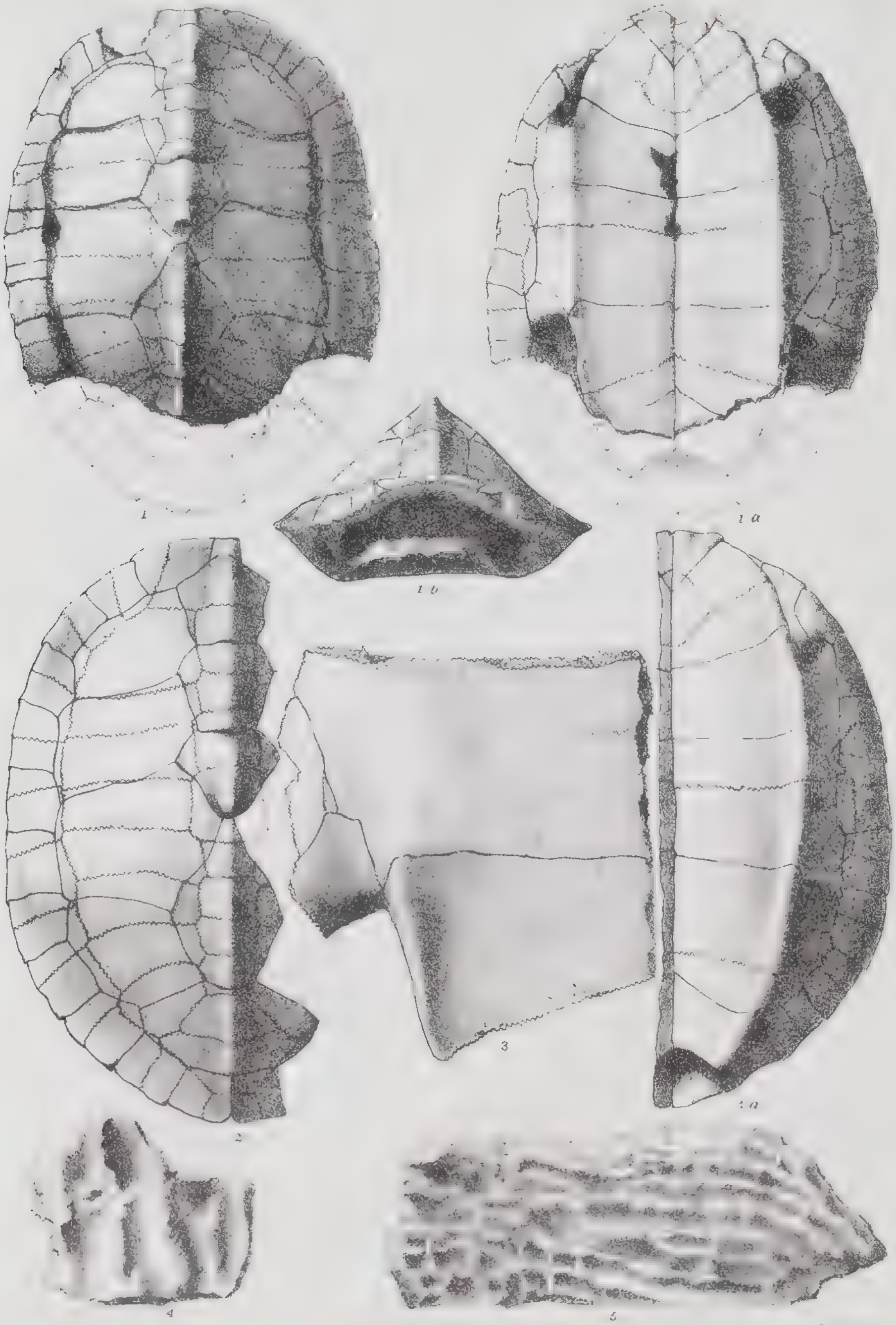
The epidermoid plates in *Pangsh. tecta*, and other allied species, are subject to a great deal of variation, which is especially considerable in the form of the vertebral plates, occasionally so much so that they cease to be of great specific importance. The most variable are the first and the fifth vertebral plates. In the Indian Museum there exists a remarkably large specimen of *Pangsh. tecta* from Cachar. Its first vertebral is pentagonal, the second quadrangular, third rather large, of regular form, fourth very large, bell shaped, the fifth is three-fifths of the length of the former, of almost equal width throughout, truncate in front, sub-angular laterally, and obliquely pointed posteriorly, while, as a rule, it is truncate behind (see fig. 2, pl. 1). There are twelve marginals on each side, instead of eleven, the tenth being divided by a furrow in continuation of the suture which separates the fifth costal from the fifth vertebral. The caudals are very small.

Comparing the epidermoid shields of some of the specimens of *P. tecta* with those of *Pangsh. tentoria*, it is by no means easy to point out any very remarkable distinctions, but the latter species can be always recognised by its broad, depressed back, the sides of the carapace being distinctly convex, and the general form of the shell more elongated. (See Theobald's Catalogue of Reptiles, etc., Jour. Asiat. Soc., Bengal, Extra No. 146, 1868, p. 14). Günther's figure of *Pangsh. tentoria* is by no means characteristic, being almost undistinguishable from that of *P. tecta*.

The costal shields are, on the contrary, much more constant, and they do not appear to vary essentially in allied species and genera. In all the species of *Pangshura* which I have examined they were arranged quite identically.

Mr. Theobald proposed for the specimen here figured the new specific name "*Namadicus*," while Dr. Falconer, in an essay already written in 1844 (see Falconer's Pal. Mem., Vol. I, 1868, p. 382), had identified another specimen found in the Sevalik strata with the recent species. The examination of the Nerbudda specimen has strongly confirmed Dr. Falconer's investigations; that celebrated naturalist summing up his results in the words, "that we are not justified in constituting a difference where we do not find it." Judging from all the solid parts of the carapace, it cannot, I think, be reasonably questioned that the Nerbudda and the Sevalik fossils, as described by Dr. Falconer, are both of the same species, and identical with recent specimens of that species. It might, of course, be said by some naturalists that the fossil specimens may have been, for instance, quite differently coloured, and this would be sufficient to constitute a specific distinction. Such hypotheses cannot, however, be admitted as having any value in pointing out specific distinctions of fossils.

I have no doubt that the specimen from which Dr. Falconer's description was taken is a true *Pangsh. tecta*, but it seems very doubtful that it was the identical specimen figured by Dr. Murchison on Plate 32 in Falconer's Pal. Mem., Vol. I. I have little doubt that this last one is also a *Pangsh. tecta*, but it can scarcely be the identical specimen which Dr. Falconer described. Dr. Murchison (in a note on page 382) pronounces the figured specimen to be the original of Dr. Falconer's description, but when writing the explanation to the plate some of the differences must have struck him, and here he leaves the identity of the specimen doubtful. On page 383 Dr. Falconer says, with reference to the first vertebral, (of the epidermoid coat), "the exact form is not distinctly seen, though it seems to converge less * * *." In the figure two-thirds of the first vertebral are broken off, and no convergence is perceptible. Farther, the author says, "the outline of the fourth scute is not distinguishable in the fossil, and the fifth one is wanting." In Dr. Murchison's figure the fifth shield appears perfectly preserved. With regard to the fourth vertebral scute there is an error in Dr. Murchison's figure. The draughtsman has in place of the outline of the epidermal shield marked the outlines of three osseous plates, and of these he does not seem to have given the outlines quite correctly. The fourth epidermoid vertebral scute extends over three complete osseous vertebrals and an additional one-half, or nearly that, on either end (see pl. I, fig. 2). It is important to point out this distinction, though every one, looking at Dr. Murchison's figure, will readily notice that some mistake of that kind must have occurred. For no *Emys* or *Pangshura* possesses seven scutes in the epidermoid covering, and if intended as a representation of osseous shields, the number is, as I have already stated, too small. In spite of this discrepancy and the somewhat strongly bi-tuberculated second vertebral scute, I can hardly think that the specimen figured by Dr. Murchison belongs to any other species than *Pangsh. tecta*.


1
1 a
1 b
2
3
2 a
4
5

BATAGUR SP., *conf.* DHONGOKA, *Gray*. Pl. I, Fig. 3.

Günther's Reptiles of India, Ray Soc., 1864, p. 42.

One right abdominal osseous shield has been found in the conglomeratic beds near the village Omeria. This abdominal osseous shield is 108 m.m. long and 94 m.m. broad in the region of the inguinal process. Its form, the flat surface and the outlines of the junction of the abdominal and præ-anal shields, of the inguinal and of the adjoining marginal on the external side, entirely agree with the form of the same shields of the recent *Batagur dhongoka*. Further materials are, however, necessary to show whether this supposed identification be correct.

The species occurs at present throughout India, especially in the larger rivers, and it is found up to the present time in the Nerbudda. Judging from the size of the fossil shield, the specimen to which it belonged must have been about one foot long; specimens much larger than this are met with alive now in India.

TRIONYX SP., *conf.* GANGETICUS, *Cuvier*, Pl. 1, Figs. 4—5.

Günther's Reptiles of India, Ray Soc., 1864, p. 47.

The two fragments which are referrible to the above species consist of the largest portion of the left lower inguinal plate, and a fragment of one of the bony (sternal) processes with broad longitudinal furrows. The rugose surface of the inguinal plate entirely agrees with that of *Trionyx gangeticus*, and this is the only reason which can at present be brought in support of the presumed identification of the fossil with the recent form. The thickness of the plate shows it to have belonged to a large specimen. These two fragments were also met with in the conglomeratic bed near Omeria. *Trionyx gangeticus* is found at the present time living in most of the large Indian rivers, especially in the Ganges and its tributaries.

We have thus up to the present three species of Chelonia upon record from the newer tertiary fluviatile deposits of the Nerbudda valley. These all belong to forms which live in fresh water, and so far agree with Mr. Theobald's conclusions, derived chiefly from a consideration of the shell-fauna, that there are no traces of any estuary or brackish-water deposits. Of these three Chelonia we may accept with the highest probability the identity of *Pangshura tecta* with the existing species, and the great similarity of the other two to existing species is also unquestionable. The Chelonia, probably unnoticed by man, appear to have changed far less in the lapse of time than the Mammalia. The *Pangshura tecta*, and probably two other species (not yet known to occur in the Sevaliks proper), have then continued to exist unaltered, from the time of the *Sivatherium*, *Mastodon*, various *Elephants*, *Hippopotamus*, *Colossochelys* and others, down to the present time. The changes in the conditions of climate, &c., may not have been great, and if the species of reptiles survived these changes man surely would have been able to do the same, had he existed at that early date. That he did so exist, and that he was a contemporary of the *Colossochelys*, as Dr. H. Falconer suggested long since, we have no reason to doubt, although as yet we may not be able to adduce any direct proof of the fact.

EXPLANATION OF PLATE I.

Figs. 1, 1a, 1b; dorsal, ventral and front views—half the natural size—of the carapace of a fossil specimen of *Pangsh. tecta* from newer tertiary conglomeratic beds near the village Moar Domar in the Nerbudda valley.

Figs. 2 & 2a; dorsal and ventral views of half the carapace of a recent specimen of the same species; (natural size).

Fig. 3 ... Ventral view of a right abdominal osseous shield of a species closely allied to, or identical with, *Batagur dhongoka*, Gray, from the same beds as Fig. 1; (half of natural size).

Fig. 4 ... Portion of the sternal process of a species closely allied to, or identical with, *Trionyx gangeticus*, from the same beds as the last; (half of natural size).

Fig. 5 ... View of a fragment of the inguinal plate of the same species as the last, and from the same locality; (natural size).

Sketch of the Metamorphic rocks of Bengal, by H. B. Medlicott, A. B., F. G. S., *Depy. Supt., Geol. Survey of India.*

From the descriptions of the earliest geological observers in India it has been known that large areas are occupied by metamorphic and submetamorphic rocks. It might not appear from its publications that the Geological Survey had given to these formations their due share of attention. But such an inference would be far from correct: coloured maps of large districts might long since have been published, with a general description of the lithology and of the superficial stratigraphical features; and specious analogies might have been drawn with the 'fundamental' rocks of other countries; but any such accounts would be illusive without some definite judgment upon the structure and relations of the several rock-groups. The following notice is a brief abstract of observations made by me during two seasons (1862-63, 1863-64) spent on these rocks, from the watershed of the peninsula near Jubbulpur, in an east-north-east direction, to Monghyr on the Ganges, a direct distance of more than 400 miles. Those who have any knowledge of the difficulties attending the investigation of such rocks will at once understand that my explanations can be only tentative.

The broad promontory round which the Ganges turns at Rajmahal is the termination of a great expanse of gneissic rocks. Here, throughout its eastern extremity, for nearly 100 miles, the gneiss is covered and bounded by the Rajmahal Trap, with its associated plant beds (jurassic), locally underlaid by other members of our Indian Stratified Series; and various outliers, of irregular shape and size, of these latter deposits, comprising our best known coal-fields, are scattered over the area to the west; but from the Rajmahal boundary the gneiss is continuous for 400 miles to the west-south-west to where it passes under the Great Deccan Trap (supra cretaceous) of the Mundla plateau. From the south extremity of the Rajmahal Trap the general boundary of the metamorphic area extends to the south-south-west. Across the middle of the area a straight line might be drawn for more than 150 miles from north to south, continuously on crystalline rocks.

Throughout the greater portion of the northern boundary (the region to which my observations more especially refer), and with few exceptions wherever rock is more exposed, the gneiss is in contact with submetamorphic rocks—slates, schists and quartzites. The exceptions are where, only very locally, the Lower Vindhyans lap on to the gneiss, and where the crystalline rocks themselves extend through and beyond the otherwise regular and continuous run of the schists. This latter case is a most important one; it occurs in about the middle of the region, and is connected with an interruption of nearly 80 miles in the run of the schists, dividing them into two separate areas, and introducing all the doubts and difficulties of identification. In the western area the submetamorphics are continuous along the south side of the Sone valley and into the Nerbudda valley, and are throughout the whole extent bounded on the north by the great Vindhyan range, the strata of which rest totally unconformably upon the schists. In the eastern area, in Behar, the slate series appears in detached groups of hills more or less isolated in the deposits of the Gangetic plain; the principal of these hills are those of Rajgir, Kurrukpur, Ghiddour, Bheowa, and Mahabur. There is perhaps a presumption that the analogous rocks in the two divisions of this great zone are closely related, but many circumstances combine to complicate the question of identification: in the western area the rocks are principally argillaceous, and the metamorphic products of such; while in the east, quartzose deposits largely predominate. Again, this break of continuity is coincident with the eastern extremity of the immense spread of the Vindhyan rocks, and thus, through a general analogy of composition, the possibility was at first suggested (the crystalline rocks not being necessarily all of one period) that the quartzites of Rajgir, &c., might be altered Vindhyans. This supposition may, I think, be quite set aside: the Lower Vindhyans near their eastern limit rest quite unaffected upon the granitics; and the most peculiar and characteristic beds of the Lower Vindhyan series are most extensively developed in this position, yet there are no rocks among the submetamorphics of Rajgir that would even approximately represent them specifically. There is, on the other hand, no inherent difficulty to the general equivalence of the submetamorphic series in the two regions, in the fact of there being much difference of composition at so considerable a distance. It need hardly be stated that only the leading relations of the rocks are to be noticed: no fossils have as yet been discovered in any of them, and no detailed work has as yet been attempted.

The superficial relation of position—a great spread of crystalline, fringed by submetamorphic rocks—is already variously suggestive: the rival leading questions would be—to what extent are the crystallines granitic and intrusive, thus determining the present limit of the schists? or, if the crystallines are in the main gneissic and themselves metamorphic, how far may the present limitation of the submetamorphic series as a fringing deposit be an original feature? No satisfactorily one-sided answer can be given: the facies of the crystalline rocks is emphatically gneissic (metamorphic); there is also ample evidence of granitic intrusion in the rocks of both series; yet, owing to theoretical scruples, and to deficiency of data, the residual phenomena are so numerous that no approximately final judgment can be put forward even as to the main relative ages. It is time, however, that our difficulties should be ventilated. The lie of this great band of slaty rocks, on the south of the Gangetic valley, and followed up, as it is, by the next succeeding deposits of the Vindhyan series, suggests at first sight inferences as to the possible substratum of the great alluvial formation, as to the inducing conditions for the great area of erosion or of depression, and as to possible relations to the rocks on the north of the plains, in the Himalayan region. But, whatever independent interest these large structural features may retain, such speculations as those mentioned are in a great measure negatived by the appearance to the north of the Vindhyans in Bundelkund of a large area of thorough gneissic rocks; and again, in Behar, in the small group of the Barabar hills, well to the north of the Rajgir range, we find very massive gneiss of most ancient aspect.

I must here briefly recall to notice some observations I made in 1856-57 in a neighbouring part of India (published in the 2nd Vol. of our Memoirs) as bearing upon the question before us. To the north-west of the Sone valley, and separated from it by the long eastern prolongation of the Vindhyan formation, there is the large area of crystalline rocks of Bundelkund; it is bounded on three sides by the Vindhyans and on the fourth by the Gangetic plains. Along the south-east border of that area there appears a strip of semimetamorphic rocks—quartzites, limestone* and slaty strata, with contemporaneous trap, rising from beneath the Vindhyans. I described them as the Bijawur formation. They are in many places seen to rest abruptly upon a flatly denuded surface of the gniess of that area. The bottom rocks in this position are peculiar quartzites, often compact and brecciated, and massive cherty limestone; but along portions of the boundary the usual Bijawur strata are underlaid, with at least approximate parallelism, by very non-descript gneissoid strata. The demarcation between these and the true gneiss is, naturally, very obscure; and it was not then possible to work it out; but there are locally some intercalated beds of quartzite-sandstone that effectually betray the stratigraphical affinities of these indeterminate strata to be towards the Bijawur rocks, and totally distinct from the true gneiss, to which they seem in the relation of an ancient superficial covering. We shall see that probable representatives of the Bijawur rocks occur both in the Sone valley and in Behar; and that thus we may at least get a hint as to the relative ages of the gneiss of the two areas.

A large part of the submetamorphic area of the Sone valley is occupied by rocks that would well represent the Bijawurs—ferruginous slaty schist with quartzite, limestone, and much contemporaneous trap. They are much more disturbed than in Bijawur; it is even probable that they are affected by certain granitic intrusions. The uncertainty upon this and upon other unsettled points regarding their relation to the main crystalline area to the south is largely owing to the presence of another older series of slaty rocks in the Sone area. The Bijawur deposits are known to be somewhat fickle, but unless they are so beyond all possible conjecture, there can be little doubt of the existence of this older series. In some of the best sections, notably in that of the Rehund, there is a clear transition from the coarse felspathic gneiss, through well marked stages of crystalline metamorphism, into a series of fine clay-slates, with plenty of intrusive greenstone, but in which none of the characteristic Bijawur rocks can be recognised. Where decided Bijawur rocks come in contact with the gneiss there is no such intimate relation between the two. Now that maps of this ground are available there is some prospect of our being able to unravel these obscure questions.

The hills formed of the submetamorphic rocks in Behar appear generally as precipitous ridges of quartzite, either singly or massed together in groups. Even in the

* The limestone of Dergoan, which I had doubtfully described as an outlier of the Lower Vindhyan limestone has since been shown by Mr. F. R. Mallet to belong to the Bijawur series.

latter case the inner vallies are so deeply eroded that it is often difficult to get a sight of the softer rocks contiguous with the hard quartzite. The Rajgir group is the most removed from the main crystalline area; the rocks are less altered than elsewhere; and it presents the best chance of discovering the normal order of succession of the strata. It cannot, however, be said that the strata here are less disturbed than elsewhere; although, on the whole, the strike of the ridges and of the rocks is very constant to north-east by east, the state of contortion could not well be aggravated short of presenting a great brecciated agglomeration. There are some sections in which there seem to be several hundred feet of quartzite in regular succession. At some points also the fine slaty schists present a very wide outcrop without any admixture of quartzite. Except very locally at the contact of the two there is no appearance of interstratification. It will presently be seen how essential it is to the geology of this whole region to ascertain the true order of succession of these two bands of strata. Some of my colleagues have considered the quartzite to be the bottom group; the supposition would alleviate some of our difficulties, and there are no doubt cases in which the schist now overlies the quartzite; but a close examination of the ground does not permit me to adopt this view; I consider that there is here but one great band of quartzite normally underlaid by a considerable thickness of argillaceous strata. There is only one spot at which these Rajgir rocks are seen in contact with others: along the whole south-east face of the range (at least at the several points at which I crossed it) nothing is seen immediately external to the quartzites; at about a mile from the base on this side there is one small outcrop of massive granitoid gneiss. On the north-west side the schists are very generally exposed; and at about the middle they form a wide fringe of low hills, on the outer margin of which, near Ghunsura, there is one good contact-section of the schists with a strong mass of granite. The relation is unmistakably one of intrusion; there are small protrusions and ramifying offshoots from the granite into the sedimentary rocks, and enclosing angular fragments of them. The general effect on the schists is very noteworthy: there is little of what is usually considered as hypogene metamorphism; the line of contact is sharply defined, and the schists tend rather to assume a homogeneous, trappoid aspect, than a foliated, quartzose, granitic one; the granite of the intrusions has lost much of its quartz. Elsewhere to the west, at Sapineri, Putturkati near Gya, and Muhair, and in other isolated outcrops, these re-actions are exhibited on a much larger scale; idols and utensils are extensively wrought from the soft serpentinous rock of the converted schists; and some of the granite dykes yield a fine kaolin, the only considerable use made of which is to adulterate lime.

To the south-east of the Rajgir hills the Bheowa range stands on the border of the crystalline area; and further south, across the narrow valley of the Sukri, rises the fine hill-mass of Mahabur, well in among the crystallines, and overlooking all the high land to the south. One cannot resist identifying the great quartzites of these ranges with those of Rajgir; and at Mahabur we again find a thick underlying series of fine schists. There are, however, considerable changes to be taken into account: all the rocks are more metamorphic than those of Rajgir; the quartzites are frequently full of small innate mica; and the schists are fine mica-schists, garnetiferous, and often with much globular felspar, but still the very kind of metamorphic rock that one might expect from the slaty schists of Rajgir; and they are very markedly distinct from any variety commonly associated with the gneiss. Round the base of Mahabur I did not succeed in finding a section showing even an approximate contact with the surrounding rocks; but on the north flank of the Bheowa ridge there is a fair example of what the general relation of the two series in this region may be. At the north end of the Hurkur pass there are several fine domes of granite; they are excellent instances of a form of rock that is of frequent occurrence all over the gneiss area; a more or less faint foliation is generally traceable in it, and it never shows any attempt to throw out dykes; it would seem nevertheless highly probable that it is in some manner intrusive; the partial foliation (as Mr. Scrope has maintained) being due to traction in the viscid mass. The case before us is about the best evidence that could now be given in favor of such intrusion: one of these domes occurs close up to the ridge of quartzite, and the two rocks show distinct re-actions at the contact; the granite has lost its usual coarse porphyritic texture; the quartzite is more than usually charged with mica, and has a steep underlie from the granite; at the lower levels traces of the schists were observed. If the supposition that forces itself so strongly upon our judgment be correct, that these several hill-masses are remains of a once continuous formation of argillaceous, succeeded by quartzose, deposits, there could be no doubt left of the truly

intrusive character of these sub-gneissoid granitic masses. On the same supposition the features of these Behar rocks, as thus far described, would fall well into harmony with generally received notions upon the process of hypogene action,—that these southern portions of the formation, being contiguous to the main region of hypogene activity, have undergone general metamorphism; while that portion at a distance from the centre exhibits special and partial intrusion, with a corresponding degree of metamorphism.

I must now attempt to exhibit those rock-features of the district which can scarcely be brought within, or which would seem anomalous in, the partial view that has been represented. The former are encountered in the sub-metamorphic rocks, and the latter in the gneiss, although it seems possible to bring them under one explanation. At about twenty miles to north-east by east, exactly in the run of the Rajgir range, and having the same strike, are the small hills of Sheikhpura. They also are principally formed of quartzites in considerable thickness. Some of these could not be distinguished from those of Rajgir; many beds are tinted red, a feature not noticed in the Rajgir rock; and on the southern ridge there are schists distinctly intercalated with the quartzite. But the fact most irreconcileable with the view taken of the Rajgir series is that these Sheikhpura quartzites are certainly bottom-rocks. Along the whole face of the ridge over the town they are admirably exposed in contact with a coarse granitoid rock of very doubtful aspect. It is so thoroughly decomposed and so massive that one might readily fail to detect its true character. The quartzite, too, is steeply inclined against it, the beds in contact being of abnormal texture, and in a manner amalgamated with the surface of the rotten pseudo-crystalline rock. The section, however, at once reminded me forcibly of those I had seen eight years previously at the base of the Bijawur series in Bundelkund. This conjecture made at Sheikhpura was fully confirmed ten miles further on in the same direction, where some small hills appear on the banks of the Kiul close to the railway station of Luckieserai. The northern hill is formed of a coarse conglomerate, large and small sub-angular pieces of quartzites (I noticed none of crystalline rocks) in a matrix of gneissose schist; the dip is 50° to south. The southern hill, only about 80 yards distant, is principally formed of an amorphous pseudo-granitic rock; but in it also strings of abraded detritus can be detected. On the south side this mass is overlaid by quartzites of precisely the same description and in the same manner as in the section at Sheikhpura. This section at Luckieserai most strikingly ressembles some in Bundelkund, 400 miles to westward; and the rocks are so peculiar that whatever else is doubtful in the Behar region, I am disposed to regard it as fixed that the Luckieserai beds are strictly geological representatives of the Lower (or rather, Infra) Bijawurs. Now, the question is, can these belong to the same formation as the Rajgirs? There are several suppositions possible: I may have mistaken the true order of the rocks of Rajgir, but this I am least inclined to admit; or, the real bottom rocks may not appear anywhere in the Rajgir sections, the junction at Ghunsura having cut through them; or, both may be bottom-rocks in their separate localities—how far are we at liberty to impose any fixed order upon the deposits, especially as the Bijawurs, which are in a manner our standard of comparison, are known to be most changeable on the same apparent horizon. As if to close this last mode of escape, or to push it to the uttermost, there occurs at Bichua, within two miles to the north-east of Luckieserai, a considerable hill, much larger than those just noticed, composed entirely of fine ferruginous schists, exactly like those of Rajgir or of Muhair; it is quite isolated in the alluvium. There still remains to be tried the supposition we found necessary in the Sone Valley—the presence of two distinct series, but more or less resembling each other in general metamorphic condition. To apply this supposition in the Behar region brings us into difficulties with the gneiss of the main crystalline area: in the Sone district the Bijawur representatives would certainly be the *younger* of the two series there present; and in Behar, too, from what has been so far stated, we should start with the same view; but here we find that the series which we have independently assimilated to the Bijawurs identifies itself most closely with at least one common form of the great gneiss of Bengal.

The Kurrukpur hills form the largest of the Behar groups. The general features are very similar to those already noticed; steep ridges of quartzite rising from the low ground on all sides. Schists occur abundantly within the range. The contortion of the strata is excessive, just as in the Rajgirs. Gneiss appears close to the base on the east and south sides: and on the west and north granitic crystallines occur within short distances. The Ghiddour range lies to the south-west of the Kurruckpurs, between

them and the Bheowa ridge; here also the general appearance is similar to that of the other principal hill groups.

Upon these general considerations of similarity of structure, position, and to a great extent of composition, one would not hesitate to suppose the rocks of all these eastern groups to belong to the same formation as the Rajgirs &c.; it is the conflicting evidence of the bottom-rocks, as already noticed, that would suggest a doubt—in the best sections I have seen at the base of the Kurruckpur and Ghiddour hills, the rocks near the great quartzites resemble those of Luckieserai. Although it would still be possible that there are two series of equal magnitude, and so closely resembling, yet quite distinct, the presumable unlikelihood of such being the case would quite outweigh all the difficulties to their complete identification; and it is only on the supposition of the sections to which I allude proving deceptive that I would venture to suppose there being any separation at all among these rocks, further than what may exist between the groups described in Bijawur to which I would then consider them parallel. The case I would explain is well exhibited at the east end of the Ghiddour range: for some distance a low flanking ridge follows the curve, and close to the base, of the great cliff of quartzite; it is principally formed of a coarse schist-conglomerate, sub-angular pieces (some are six inches across) of quartzites undistinguishable from those of the cliff, even to the peculiar innate mica; still the rock is thoroughly metamorphic, with the pebbles firmly soldered to the matrix. The underlie of this rock here is 30° to 50° westwards, thus apparently underlying the rocks of the range above. At the south-east angle, however, instead of following the run of the range westwards, it trends away to south and south-east, with very low dips, and completely identifies itself with the similarly arranged gneiss, schist and subordinate quartzite that cover so much of the low ground. I have little doubt in identifying these rocks with those at Luckieserai; and it appears to me more than doubtful that they truly underlie the Ghiddour quartzites. There is ample evidence on record of younger, apparently passing under older, deposits; and without involving the inversion of either. On the strength of their much more advanced type of metamorphism, these gneissic rocks at the base of the Kurruckpur and Ghiddour ranges have been considered altogether more ancient than the rocks of the hills; but if the suggestion now made be confirmed, that order will have to be completely reversed.

The same conjecture occurred to me from an independent point of view in the neighbourhood of Mahabur. Within about a mile of the east end of this ridge, right in the axis of its strike, we find these associated layers of tough mica-schist, hornblende-schist, gneiss, and subordinate quartzite, covering considerable areas at low undulating angles of disturbance. I was quite unable to conceive how such rocks could have been where they are at the time when the great quartzites were so intensely plicated, and the schists below them received their steady cleavage. The foliation of the Mahabur schists is cleavage-foliation; that of those other rocks is strictly lamination-foliation. This mechanical objection is at least as valid as the chemical one to which it is opposed, and which would determine the relative ages by relative metamorphism. But, indeed, there is little to choose between on this score here, for the Mahabur schists are often gneissose, containing much felspar.

In connection with this question of relative ages, it is necessary to notice the structure of the ranges as related to their distribution. Their isolated positions are not simply due to denudation: it is certain that the matter removed from between them at their present common level consisted in great part of crystalline rock. Uniform as is the general strike of the ridges, the termination of the ranges does not present a serrated front; the quartzites of the outer longitudinal ridges are bent round in a sharp regular curve, forming a continuous ridge of equal or greater elevation at the curve, with a precipitous external face, and generally an equally regular converging internal underlie. This feature is more especially well marked on the eastern aspect. In the larger groups there are internal features of the same kind; the contortion presenting a two-fold system of corrugation, one of which (the east-west one) greatly predominates, producing the marked longitudinal outline of the ranges. The cleavage and its foliation in the schists have been observed to follow these same curves. It was partly upon this evidence in the Rajgir group—that one can walk from any one ridge to any other without crossing a band of the schists which appear so freely in the enclosed valleys—that I inferred the supraposition of the quartzites. The drainage of these internal valleys does not take place endways, but by narrow gaps cut through the longitudinal ridges of quartzite. Outside the hills granitic rocks are sometimes seen in front of these abrupt terminations of the quartzite ranges. Thus it would seem as if the existing masses of the sub-metamorphic rocks had occupied areas of locally greater

depression at the time of the first great granitic invasion; and that to this we may owe their ultimate preservation as hill ranges. The feature is well exhibited in Mahabur: the axis of the range would strike up a reach of the Sukri, and on each side of the river there is an elongated oval of granitoid rock, as of denuded domes. The characteristic arrangement of the doubtful gneissic rocks is also better shown here than anywhere I could mention: they appear as regular concentric coatings to the granitoid masses. The area on the south is less elevated, and the diverging dips of the covering rocks range from 5° to 20°; on the northern area they are much steeper as if exposed lower down on the sides of the mass they envelope, but the regularity of the encircling ring is unbroken, and of the same description of rock as on the south, but in thicker masses. Upon the usual evidence of regularly alternating stratification of highly contrasting materials, it is not, I presume, to be questioned that these are true detrital accumulations remineralized; and it might, I suppose, be maintained on the strength of some misunderstood process of hypogene intrusive action that they may have underlaid the Rajgir formation; or it might even be said that the stratigraphical features of the Mahabur region suggest such a relation. But from the evidence before us, I confess to a preference for the contrary supposition: it would require that after the great disturbance and metamorphism of the Rajgir series the whole area was denuded to a much greater extent than now, and that upon the surface thus exposed these accumulations took place, probably of some arkose-like materials, very susceptible to mineral reorganization. Such must have been the composition of the bottom-infra-Bijawurs.* In this Behar area, however, there is ample evidence of a later granitic invasion: in the southern tributaries of the Sukri there are fine sections of great granite dykes traversing all the rocks transversely. This granite is very different from that already noticed; it is highly crystalline; in the centre of the dyke the felspar and quartz form a coarse graphic granite, with associated schorl and beautifully plumose mica. The view I have proposed would imply a prodigious relative antiquity for the Rajgir formation.

The views that have now been presented in connection with the submetamorphic series have manifestly very direct bearing upon the rocks of the great gneissic area. Supposing the conjecture regarding the extensive representation of the peculiar infra-Bijawurs to be correct, there would be four principal geological divisions to be discriminated and mapped, exclusive of all later granites, &c. *1st.* There would be the gneissoid granite, which would seem to be largely present, to be distinguished from true metamorphic gneiss. I should despair of settling this point without the extensive application of microscopical analysis of the rocks; indeed it remains to be seen whether even this test would furnish a criterion, whether the crystals of such a rock would not assimilate more to metamorphic than to fully igneous products. *2nd.* It is more than probable that associated with that granite we should find a most ancient gneissic formation long anterior to the metamorphism of the Rajgirs, and possibly equivalent to the gneiss of Bundelkund. *3rd.* We should probably find remnants of the Rajgirs in their gneissose form. On this point there is some information at hand: far within the great crystalline area, near the Grand Trunk Road north of Burhi, there is an inlier of typical Mahabur (Rajgir) schists. If they always remain so characteristic there will be no difficulty in recognising them. Even here they are attended by the encircling ring of variable quartzites, having high converging dips towards the schists, which occupy the lowest ground in the neighbourhood on the banks of the Barrakar. The quartzites form a narrow ridge round them, and would belong to our next division. *4th.* There would be the hypothetical infra-Bijawurs. The establishment of this series would probably relieve our field work of some perpetually outcropping difficulties, especially in the shape of isolated, discontinuous runs of quartzites and breccias. But apart from these more characteristic beds, I could not now assign a lithological criterion for this series generally: as has been seen they even simulate granitic masses. Great irregularity and discontinuity is one of their features; although frequently presenting excessive contortion, as if when caught between two resisting masses, they are generally comparatively little disturbed; and what disturbance they exhibit seems to be largely determined in direction by local circumstances, resulting in great irregularities of dip. In Bundelkund, where they were first detected, these beds seem to have but little extension; but in Bengal they seem to occupy large areas: I have observed rocks of this description in far distant localities of the great gneissic area.

January 1869.

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* As a more recent parallel for such kind of deposits, I would refer to the felspathic beds of the lower Vindhyans as exposed in western Behar, to south-west of Kutumbeh.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1869. [August.

PRELIMINARY NOTES ON THE GEOLOGY OF KUTCH, WESTERN INDIA, resulting from the examination of that district, now in progress, by the Officers of the Geological Survey, by A. B. WYNNE, F. G. S., &c.

The detailed examination of this province has been long looked forward to with interest, as promising to cast light upon the geology of other parts of India where fossil land plants similar to some of those occurring in Kutch have been found to characterize an extensive group of rocks and are almost the only fossils which those rocks contain.

These plants were known to be associated in Kutch with a large number of marine fossils, the Jurassic age of which was determinable, but the relations between the beds containing forms so distinct had still to be ascertained.

With this view a hasty visit was made to the district of Kutch by Mr. W T. Blanford of the Geological Survey, in 1863, and the conclusions to which his observations led appeared in a short paper among the publications of the Survey. (Vol. VI, pt. 1.)

Except this comparatively recent paper other sources of information regarding the geology of the country, prior to the present investigations, were almost limited to a paper by Captain, since Major, Grant, read before the Geological Society of London in February, 1837; some remarks upon it by Dr. Carter in "Geological Papers on Western India" published by the Bombay Government in 1857; a record of some fossils by Colonel Sykes (Geological Society, London), and an interesting notice in Sir Chas. Lyell's "Principles of Geology," describing the effects of the earthquake of 1819, the elevation of the "Allah Bund," and submergence of Sindree village on the Runn, north of Lukput.

Of these Captain Grant's paper is the most detailed, but while it contains many valuable facts, several of these seem to have been affected to distortion by geological theories, or views, which have vanished since he wrote, and also by a misappreciation of the stratigraphic arrangement of the rocks. The four or five-fold sub-division adopted by him, being natural, is correct, though the sequence was mistaken.

THE ROCKS CLASSIFIED.

The following may indicate the ultimate arrangement of the larger rock-groups, some of the newer ones being perhaps capable of further sub-division:

RECENT AND SUB-RECENT ...	Blown sand. Alluvium. Concrete.
TERTIARY	Tertiary beds and Nummulitic do. Sub-tertiary.
	Stratified traps and Intertrappean.
JURASSIC	Upper Jurassic (? Rajmahal) Lower Jurassic ("Dogger," or Middle Jurassic.)
	Intrusive Traps.

[The syenite of Parkur-Nuggur, Kalinjur hill, &c., at the north-east corner of the Runn might be added to the above as the nearest base known for the Jurassic rocks.]

Of these the two Jurassic groups appear to have been transposed by Captain Grant under the names of "Older and Newer Secondary." The traps were looked upon as almost solely intrusive masses; their interstratification with aqueous beds being indicated at some places where association merely occurs, and at others where intrusion between stratified aqueous rocks takes place.

LOCALITY AND FEATURES.

The province of Kutch lies upon the west coast of Hindustan, about 400 miles north-west of Bombay, between the sea-ports of Kurrachee and Surat, or the provinces of Kattywar and Sind.

It is bordered on one side by the Arabian Sea and Gulf of Kutch, while upon all others it is isolated from the main land and the Thurr or little desert, by the grand and smaller Runns which are connected at the eastern side of the province. Its length from east to west is much greater than its breadth,* and, including the Runn, its area is estimated as being equal to about half that of Ireland.†

The whole province presents numerous alternations of hilly ground and open plains, sandy when covered by the detritus of the rapidly decomposing Jurassic rocks, and more earthy when underlaid by the Tertiary formation, both passing, towards the southern coast, into broad alluvial plains of ordinary Indian aspect.

The hills are perhaps as often clusters as extended in the form of ranges, though these latter do occur; and more or less continuous escarpments rising with the outcrop of some of the stronger beds are very frequent. A broken chain passes nearly east and west through the Runn islands of Putchum, Khurreer and Béla to Chorar, (in the former being flanked by a smaller range):—another borders the Runn on the north side of Kutch Proper:—one, called the Charwar range, runs east and west to the southward of Bhooj, the capital of the province: and there are lesser ranges in other parts of the district, with many clusters and isolated hills frequently conical in form.

The hills of the Wagur or eastern side of the district, take no definite direction. They are the denuded remnants of what would have been a somewhat flattened and rolling dome shaped mass if their strata were continuous instead of having been extensively operated upon by denudation.

There are no lofty elevations in Kutch; that which is reputed to be the highest, namely, Dhenodur hill, overlooking the Runn on the western side of the province giving a measurement (by Aneroid) of but 1,070 feet above the Runn; several others, however, have elevations not greatly less.‡

Nearly all the ranges and many of the hills are steeply scarped on the north, and pass by gentle slopes into the plains to the south as a consequence of their structure, the beds in general having long southerly inclinations at low angles from three parallel lines of disturbance or dislocation which extend, 1st, from Putchum Isle to Chorar; 2nd, from Lukput, along the south edge of the Runn, to Doodye towards Wagur; and 3rd, from near Roha to the neighbourhood of Butchao, passing at the northern foot of the Charwar hills. North of these lines, and just in their vicinity, the beds are much contorted, their highest inclinations being always in a northerly direction.

The trap hills, particularly those formed of intrusive traps, are frequently surrounded by precipices, or else sharply peaked; an irregular range, however, formed of, or capped by, the bedded traps, running north-west from their broadest development in the Dora hills near the centre of the province out through its western half, follows the usual rule presenting long slopes upon the dip and steep ones along the outcrop of the beds.

The northern side of the province, generally speaking, has much diversity of form, being often picturesque, while, owing to the absence of jungle and prevalence of sand, its aspect is nevertheless barren; particularly when the view lies across a parched and glaring plain edged

* According to Captain Grant the extreme length is about 180 miles, and extreme width 50.

† 'Kutch Selections,' a collection of papers by various British Officials, published by the Bombay Government.

‡ Since writing the above, the height of a mountain in the Runn island of Putchum has been taken by Aneroid and found to exceed by some hundreds of feet any elevation measured in Kutch Proper. Dhenodur hill is not a volcano—see paper by Mr. Blanford, above mentioned.

by rugged hills, beyond a bright green patch with a few lonely palms, or other trees, near some village where wheat is laboriously cultivated with the aid of irrigation, and smoky clouds of sandy dust, raised by passing cattle, are driven before the northerly blast, from which those working at the wells shelter themselves by screens.

The peculiar bare, level and extensive plain called the Runn of Kutch is not a marsh, as represented upon some maps. It is periodically covered by water during the rains, and left dry, except a few patches, shortly after they have ceased; when those lower portions on which the water has lain the longest become strongly incrusted with salt,—this frequently extending as far as the eye can reach:—its dazzling surface flickering in the mirage, which magnifies or distorts any object that may happen to be upon the horizon. The source of the salt is probably from sea water, this being said to overflow the Runn, entering by the low ground at the mouth of the Koree river near Lukput, and also at the head of the Gulf of Kutch, when the sea on the coast is raised by the continued south-westerly monsoon winds.* However this may be, the waters from Kutch itself are strongly impregnated with salt derived from the rocks, great quantities of which in solution must be carried out to the Runn whenever there is sufficient rain to fill the rivers.

Although the incrustation is not very thick, being generally from one to two and a half inches, the quantity occurring on the Runn is enormous, and the way in which fish, insects and such organic remains brought in by the sea or down from the land by the Bunass and other rivers are preserved by the salt is evidence of the strength of the solution, if that were wanting.

Notwithstanding that traces of marine denudation are slight and scarce along the southern shore of the Runn,—having been probably removed by subsequent atmospheric action—its whole aspect strongly suggests its being a gradually raised sea-bottom; a broad and slightly elevated tract called the Bunnee, lying along its southern side between Putchum Isle and Kutch Proper, being very possibly a bank or bar formed by the rivers which flow from the higher land in that direction. Over this tract coarse grass, a heathery looking tufted plant and Bâbul trees are irregularly distributed.

Some of the results of the great earthquake by which this country was visited in 1819 are still to be seen in the fallen walls of several of the towns, in the "Allah Bund,"† a low elevation, thrown up by it, which is said to have permanently arrested the southward flow of the water of the Koree or eastern mouth of the Indus, and in the submerged village of Sindree on its left bank; part of the ruins of the fort only being visible above the mud, salt and water by which they are now surrounded, no other trace of the village remaining, and the basements of the building seen being buried in the silt.

Tradition has it that this was formerly the site of a large city surrounded by villages and fields, and to which the tidal ebb and flow reached: subsequently (from elevation of the land probably) the river became so shoal that boats could not reach the port; the city was in a great measure abandoned, and another Sindree built several miles further down the river at a place called Sindu on the map. Here the same thing recurred, and Sindu was deserted, a new city rising at Lukput, once an important place, but now consisting of a few houses in one end of the walled in enclosure. At present boats cannot come even so far as this, and Lukput Bunder is at a distance of three or four miles, while the sea trade is conducted at Kotaisir close to the old mouth of the Koree river. How far the first part of this statement may be true is involved in considerable uncertainty, but it is said there are records in the *Duftter* at Bhooj which would prove the accuracy of some portions of it at all events.

JURASSIC ROCKS.

The Jurassic rocks occupy a large portion of the northern half of the province extending through it almost from end to end, and also forming the hilly parts of the Runn islands before mentioned. The bold scarps and rugged hills exhibit numerous fine sections, showing plainly the structure of the country through which, notwithstanding repeated rolling undulations of the beds and some very marked anticlinal flexures, many recurring southerly and

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* It does not appear to what extent this has been proved, though from the aspect of part of the coast. it seems likely to be the case.

† Mound of God.

south-westerly dips place the lowest beds along the north side of the district, except where a great fault coinciding with the northern foot of the Charwar range causes them to re-appear in its centre.

These lower Jurassic beds consist mainly of gray, blue, red and black shales, thick and thin light-coloured sandstones and hard silicious flags, with some more calcareous varieties, and in some places quantities of dun-colored and gray compact earthy or sandy limestone. Pale-purple sandstones and some highly ferruginous bands also occur, the whole presenting so many varieties of color and kind that its general lithological aspect is seen to differ from that of the uppermost Jurassic rocks, sufficiently to warrant an attempt at sub-division, only by regarding the group as a mass and leaving details aside. The passage from the lower beds to the upper is so gradual that no very definite boundary can be assigned between them. Still there is a difference at the extreme ends of the series which would at once prevent their being mistaken for each other, and which, it is supposed, led to their separation into two groups by Captain Grant.

Owing to the numerous faults, undulations and the general lowness of their dip, the thickness of this great series of Jurassic rocks is difficult to determine with accuracy, but it has been assumed, from observations in the part of the district lying eastward of Bhooj, to reach from 4,000 to 5,000 feet, of which measured sections of over 2,000 feet have been made in the lower portion of the group; and there is no reason to suppose its aggregate thickness to be less in the western side of the province. Throughout this large accumulation of strata there is a marked absence of regular zones, indicating successive stages of deposition, and while in such an assemblage of coarse sandstones and muddy shales with frequent conglomeritic beds much constancy of lateral extension might not be looked for, and marks of succeeding zones be probably obscure or absent, no want of material seems to have existed to supply new or similar layers for those which may have died out. The whole formation, particularly in its upper beds, maintains the same characteristics of obliquely laminated strata alternating with finer and more parallel deposits, all of richly varying tints, from black to white, blue, red, orange, brown and gray, and sometimes green with a peculiar golden oolite among the lower rocks which glistens like avanturine.

The lower beds on weathering take frequently a rusty color, and dull olive tints are common, while, where the beds are highly calcareous, a whole mountain formed of them with rounded outlines and a whitish hue in sunshine looks cool, and in cloudy weather as gray as any granite hill. Thick bands of a warm orange sandy limestone with some red beds occur also in the lower rocks, and many of their shales are gypseous.

The upper beds are marked by a predominance of clean white gravelly sandstone with some blackish ferruginous bands and white or lavender-gray, sometimes highly carbonaceous, shale. Between these and the lower beds alternations of almost every variety of rock in the formation occur, ranging through a vertical space equalling a third of the total thickness if not more. Many of the beds in both groups are strongly saline.

The lowest beds are much the most fossiliferous, and the remains are chiefly marine, including *Ammonites, Pleurotomaria, Ostrea, Trigonia, Cucullæa, Corbula, Gryphæa, Modiola, Terebratula*, and numbers of other bivalves, *Echinida, Crinoids, Corals, Belemnites*, fish teeth, reptilian bones, and fossil wood.

In one certain and one or two doubtful instances some of the upper beds of this lower and marine series were found to contain impressions of (terrestrial) *Zamiæ* in shaly bands interposed between the marine shell-bearing beds. During the examination of Eastern Kutch, the most exhaustive search that could be made failed to find any thing among the upper rocks except these *Zamiæ* and a few other terrestrial plants, but in the west, in a few cases, some marine fossils have been obtained from single beds occurring amongst unfossiliferous strata of the upper portion of the rocks, but still below the uppermost (white) beds seen.

This alternation or intercalation of the marine and freshwater beds (presuming those containing *Zamiæ* to be of purely freshwater deposition) being one of the points to which attention was specially directed, it is satisfactory to have so far ascertained the fact after many months of close search, even though such alternation appears to be much more limited than was supposed, unless it is taken for granted that the numerous fragmentary grass-like plant remains so common in the shales and flaggy sandstones throughout the formation are of freshwater deposition also. Many of these have been searched over and over again

without a trace of a *Zamia* leaf being found, and there seems to be no more reason for supposing them freshwater than some other beds in which ammonites occur lying among a mass of vegetable remains, the woody fibre of which is generally distinguishable, though often obliterated by carbonisation.

Such intimate association of the *Zamiæ* with marine forms has not, it is true, been discovered, but nevertheless it may not be unreasonable to suppose that these plants were floated out from land, and deposited by the sea at depths unsuited to the marine life of the period or at localities where this was from other causes absent. As Mr. Blanford has observed in the paper above mentioned, 'no sudden change in the rocks nor any unconformity has been found to mark the transition from a salt to a freshwater period;' and while it is evident that land plants may be carried out to sea, though marine organisms cannot so readily find their way into freshwater deposits, it is easier to believe that the whole of these salt Jurassic rocks are of marine origin than that repeated alternation of fresh and salt water beds takes place without any marked difference of character or aspect occurring in the rocks.

It may also be observed that though there are but few evidently marine beds, and these not immediately associated with Zamia-bearing rocks in the *upper* part of the Jurassics seen, still these *Zamia* beds contain plants only, no freshwater shells, fish, nor animal remains occurring to contest the possibility of the containing rocks being of marine or perhaps estuarine formation.

Great as is the thickness of the Jurassic beds, it is that only of a portion of the group the base of which is not visible, and the upper beds being unconformably overlapped by the Bedded Trap, they may continue to increase in quantity beneath the latter much further than they can be observed. There are, however, some appearances, along their uppermost boundary, which may be slight indications that the Jurassic period was drawing to a close, and that the deposition of rocks much resembling some of their upper beds ushered in the commencement of the succeeding unconformable tertiary group in those places at least where this succession was not interrupted by the accumulation of the intervening Bedded Trap.

TRAPS.

By far the largest part of the trap rocks is referrible beyond a doubt to the same period as the vast stratified accumulation known as the Deccan Traps. Some of the lowest flows are very thick, presenting few or no traces of bedding for more than 100 feet, but further up this is as plain as all the other appearances, such as beds of red bole, alternations of amygdaloidal and columnar basaltic flows, presence of zeolites, and so forth, which characterise the formation elsewhere. The trap is sometimes magnetic, and among its lower beds ashy sandstone or calcareous bands occasionally exist. In one place near its local base an interstratified bed of friable red sandstone 30 feet in thickness was observed, and in another a small lenticular deposit of intertrappean calcareous rock containing small fish scales.*

The flows or beds have a low steady southerly or south-westerly inclination, forming a wide hilly belt through the centre of more than the western half of the province, but their deposition does not seem to have extended to the place occupied by the eastern extremity of the district. The thickness of this formation is much less than usual, being estimated at about 2,500 feet.

An obscure group of earthy sandstones formed largely of trappean materials, often indistinctly bedded and containing woody plant impressions, occurs in several places, having but indefinite relations to the lower part of the Bedded Traps, but resting quite unconformably on the Jurassic rocks and often closely associated with masses of intrusive trap near which also white sandstone is often strongly columnar.

The intrusive traps—occur chiefly in the Jurassic area, and probably mark some of the places from which those just mentioned issued.

They consist generally of augitic or basaltic traps varying in color (different black and grayish hues), and in texture from a close compact rock to one coarsely crystalline, the crystals of glassy felspar being interlaced, and the deeply weathered soft light-colored surface taking

* Within the last few days information has been obtained of the discovery by Mr. Fedden of intertrappean beds, containing *Physa Prinsepii*, in the western extension of the trappean formation, furnishing still further proof of the identity of these with the Deccan Traps.

much the appearance of a syenite in similar condition. Fine muddy-looking or ashy trap, weathering to an olive-green minutely divided detritus, is another variety. Some of the dykes, &c., are of fine-grained purple colored trap, with white steatitic specks, a soft earthy or lava-like texture, are much less dense than the varieties abovementioned, and are sometimes salt to the taste.

With regard to the manner in which all these intrusive traps occur, nothing could well be more varied: dykes are particularly numerous in some localities; they also occur in faults, while local intrusions form hills projecting from the plains and Jurassic broken ground, like knots in decaying wood. In such cases, their outlines are either conical or combinations of this with steeply scarped forms. Some intrusions range through the country for many miles, presenting the most irregular lines both in plan and elevation, cutting across the aqueous strata, including large masses, intruded between them or forming hills either capped or underlaid by the Jurassic beds, or both one and the other, these being altered by the contact into various kinds of porcelainous or quartzitic rock, while one case occurs where a whole stream section of the aqueous rocks seems to pass by gradual intensity of alteration into solid trap in which planes resembling the original bedding can be traced for some distance as if the strata had been melted *in situ*, no marked difference of texture however existing in the trap, although the stratified rocks consist of alternations of calcareous sandy and thin shaly bands.*

Other instances occur in which sandstone seems to have been completely melted and taken up by these traps; the matrix having yielded first and the quartz fragments and grains gradually becoming more separated and disappearing until they are quite lost at a very short distance in the dark trap. This can be seen in hand specimens.

Generally speaking, these large intrusions have an intricacy of arrangement forming a tangle which defies all effort at accurate representation upon a map of small scale, and sometimes their basaltic trap is so magnetic as to deprive compass bearings taken from these points of any value, the variation being of inconstant amount.

SUB-TERTIARY GROUP.†

As already stated, the Jurassics or Dogger beds of Kutch, consisting of a calcareous or sandy and shaly marine series below, passes upwards into alternations of more ferruginous and more purely argillaceous and arenaceous beds,—in which land fossils (Zamiæ, Ferns, &c.) are either rare or locally numerous,—these forming what are at present considered an upper member of the same group. At some period subsequent to the Jurassic, not clearly marked, but arguing from local as well as distant sources of information (in the Deccan and at Bombay), probably an early Tertiary one, the volcanic activity which produced the Bedded Traps came into operation. Observations here only show that traps were extensively intruded through the Jurassic rocks, and that other traps, very probably connected with these as centres of eruption, constitute a thick series resting with marked unconformity upon these Jurassic strata.

But overlying the Bedded Traps and, where these are absent, the rocks upon which they rest, is a marked band of most peculiar aspect, having, in contact with these traps, a very volcanic appearance, but one entirely different from theirs. Its predominant colors are deep red and pure white, but it is finely varied with purple, orange, greenish, brown and black or blue tints, even brighter and more strongly contrasted than those of the Jurassic beds. Its lowest stratum in junction with the uppermost of the trappean flows is a curiously mixed and mottled one, brecciated, concretionary on a large scale, in places containing small white quartz grains, but generally consisting of a pure chalk-white or variegated purple and lavender, unctuous, argillaceous, rock occasionally saline and speckled with white kaolin patches, giving it the appearance of an amygdaloid, sometimes to such a degree that it becomes undistinguishable from the purple trap found in several dykes among the Jurassic rocks.

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* This passage as it were of stratified into intrusive amorphous rock is so very peculiar that it may perhaps be deceptive. A place where the alteration of the beds ceased laterally and the trap might be said to commence was sought for in vain, and the lines which may be, or at least simulate, original stratification apparently continuous with those of the unaltered bedded rock cease to be traceable beyond a few yards into the trap.

† The name Sub-Tertiary used here is only provisional. An examination of the fossils will probably cause it to be altered for another. It merely means that the beds are below the highly fossiliferous Nummulitic and other Tertiary beds though above the Bedded Traps the Intertrappean beds of which are believed to be of Lower Tertiary Age.

Along the line of junction with the underlying Bedded Traps their uppermost layer is very commonly a greenish amygdaloid, also more or less generally concretionary, rusty or decomposed looking; instances occurring in which the concretions of the mottled rock have been found to exhibit an apparent passage towards their centres from one variety to the other, the cores being formed of rusty amygdaloid quite similar to that beneath. In other cases the lowest stratum of the mottled series or uppermost one of the trap is a pale greenish earthy trappean looking rock, not quite so concretionary as usual, with much of the external character of the mottled breccia, but containing yellowish green steatitic amygdals. Where these sub-tertiary beds rest on the Jurassic rocks the peculiar brecciated white bed is seldom strongly developed, but still is frequently present.

This breccia passes upwards within greater or less distance, as the bed is thick or thin, into gnarled and ponderous laterite of various red, black, brown and purple tints, either brecciated or of the brick-like character so well known elsewhere.* Its junction with the white rock below often shows rough stalactitic looking masses of the laterite vertically penetrating the lower bed all along the line of contact as if infiltrated from above. In the same group are other bands of laterite and some very coarse obliquely laminated white quartzose and ferruginous sandstone containing much of the white earth distinguishing the lower layer. Associated with these, but not always upon the same horizon exactly, are dull purple, brown and black, in some places highly carbonaceous, gypseous or pyritous shales containing numerous impressions of large and small *exogenous* and *endogenous* leaves. These occur also in fine flaggy pale lavender or white beds of the same group, but of uncertain place.

Apparently among gypseous reddish shales of this group a thin band was found to contain *Fasciolaria, Arca, Nucula, Cyprina* and *Venus,* which are not, however, in such a state of preservation as to warrant more than an opinion at present that they may be of either cretaceous or eocene age, while some bones of large reptiles, including part of a skull, have been found in very similar shales and on what seems to be very nearly the same horizon.

Close above these some brown flaggy sandstones containing a few shark's teeth and shells and occasional beds of earthy orange mudstone begin to appear, and indicate the approach to others abounding in tertiary fossils.

The thickness of this group (the 'Red—? New Red-sandstone' of Grant) varies much, from a mere band consisting of a few beds or only one, to a maximum, in some places, of between two and three hundred feet. Until the fossils have been examined, it is obviously difficult to say how much of this group may be of Tertiary age, if indeed it be not entirely so. It forms a marked basement to that series however, and where it rests upon the Jurassics without the intervening trap, its junction very commonly appears quite conformable, the line, however, being almost impossible to see when the gypseous shales of the one group overlie those of the other.

TERTIARY FORMATION.

As the Tertiary rocks are still undergoing examination, they can be but slightly noticed here, although they form a large and important feature in the geology of Kutch.

Their principal development takes place in the southern half of the western side of the district, where they form wide rolling plains under which the beds undulate, wrapping round the western termination of the Jurassic and Trap formations, and appearing at intervals along the southern shore of the Runn, on the margin of at least one of its islands, and at a few spots in the eastern portion of the province.

They consist, as a mass, of rubbly shales interstratified with yellow mudstone bands, and thick beds of sand or sandstone. Occasionally the rocks become sufficiently calcareous to be called limestone, and most of those containing fossils are highly so—an agglomeration of shell-casts in an earthy or sandy calcareous matrix.

Among the lower beds *oysters* and *turritella* are particularly numerous, whole beds being formed of the latter, and a flat echinus (*clypeaster*), being very common.

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* At some localities in Eastern Kutch the laterite is associated with quantities of Agates both *in situ* and left in a thick layer by its weathering down, strongly recalling the appearance of some very similar ground similarly situated near the base of the tertiary rocks in Guzerat.

At a short distance above the base of the formation, on an average not more and often greatly less than 200 feet vertically, are soft and harder white calcareous beds crowded with *nummulites* and *fasciolites*, the former of several kinds, and associated with them are numerous *echini*, bivalves, &c.

The Nummulitic beds are generally nearly horizontal; they produce ground of singularly barren aspect, reminding one of the Egyptian desert, the white nummulites weathered out lying thickly upon the surface in place of soil, and from their abounding in that neighbourhood being called by the native Lukput paisa.

For several miles eastward of Lukput, along the edge of the Runn, these rocks are brought against the Jurassics by a fault, and having followed the low ground round the western limits of Kutch they disappear for a considerable space in the country north and north by east of Jackow, but set in again in the low lands further east.

In other parts of the low country, unoccupied by the Nummulitic group, highly fossiliferous tertiary rocks abound, containing a large number and great variety of genera, including *turritella*, *ostrea*, *conus*, *fusus*, *voluta*, *strombus*, *natica*, *trochus*, *oliva*, *cassis*, *cerithium*, *scalarium*, *cyprœa*, *balanus*, *pecten*; *clypeaster*, *cidaris*, &c.:—of crustacea, some well preserved crabs, besides large bones and great molar teeth, and very many other interesting fossils, complete lists of which it is hoped will hereafter appear.

The thickness of these rocks is not yet sufficiently clear to be stated, but is considerable, probably exceeding 500 or from that to 800 feet.

It seems most likely that these Tertiary beds have been deposited in shallow water under shore conditions and subject to causes producing great irregularity of deposition. The occurrence of leaf beds in the group repeats the case of the Jurassic beds with regard to the alternation of fresh and salt water periods, and among the upper beds the predominance of sands almost devoid of organic remains indicates a different state of things from that under which the highly fossiliferous strata accumulated.

POST-TERTIARY.

In several places a coarse concrete is found containing numerous fossil oysters, generally of large size. It appears to rest unconformably upon the Tertiary rocks, and may be an old member of the coast series or "littoral concrete" of Western India.

Other post-tertiary and superficial deposits, such as alluvium, blown sand, river concrete, and a rock much resembling the latter, found high upon the uanks of many of the hills, have merely to be mentioned, their occurrence here being in all respects similar to that in other localities.

Coal is often mentioned as occurring in Kutch. Carbonaceous shales have been met with in several places both in the Jurassic and Tertiary rocks, but chiefly in the former, and these sometimes contain layers of bright coal. This is usually very thin, forming but small parts of the bands quite too limited in thickness and extent (so far as known) to repay the cost of working.

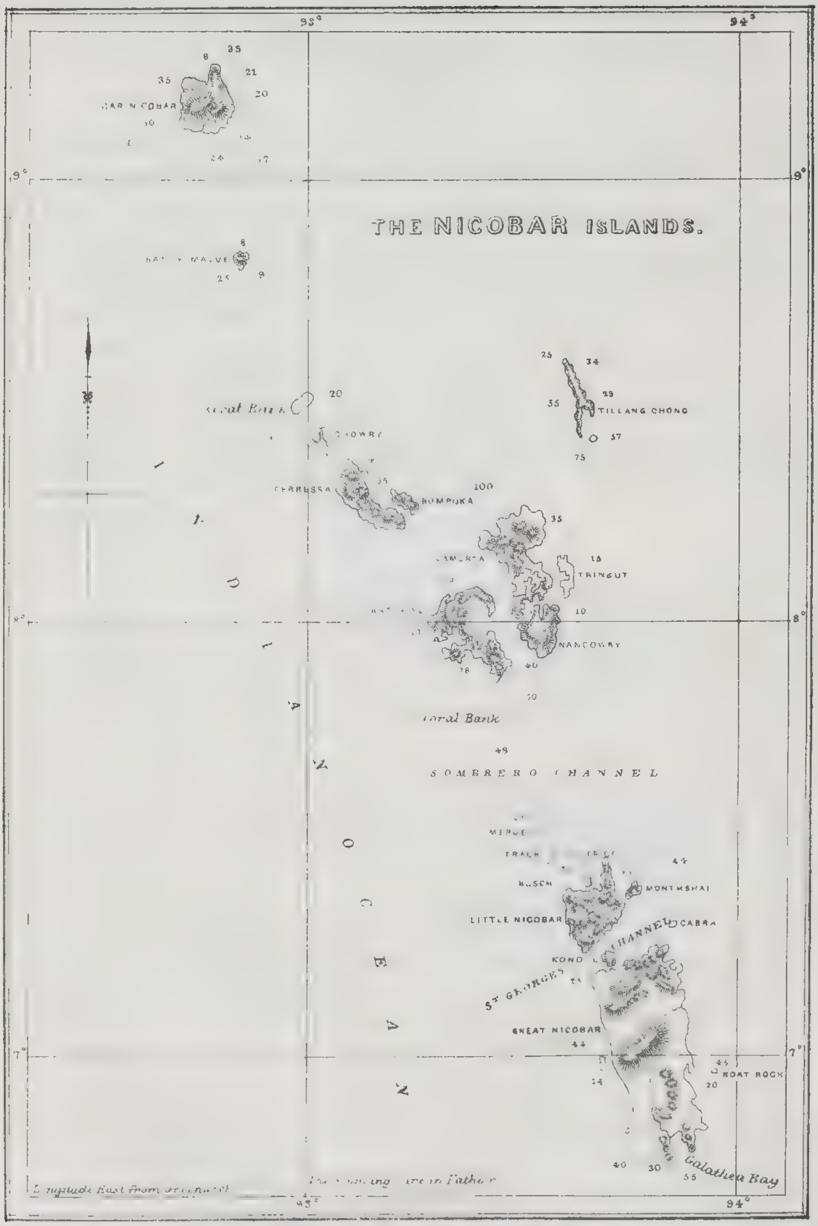
The largest layer, opened upon formerly at the village of Trombow, north-north-east of Bhooj, is now concealed by the workings having fallen in.

Alum is extracted in considerable quantities from the sub-tertiary shales of Western Kutch.

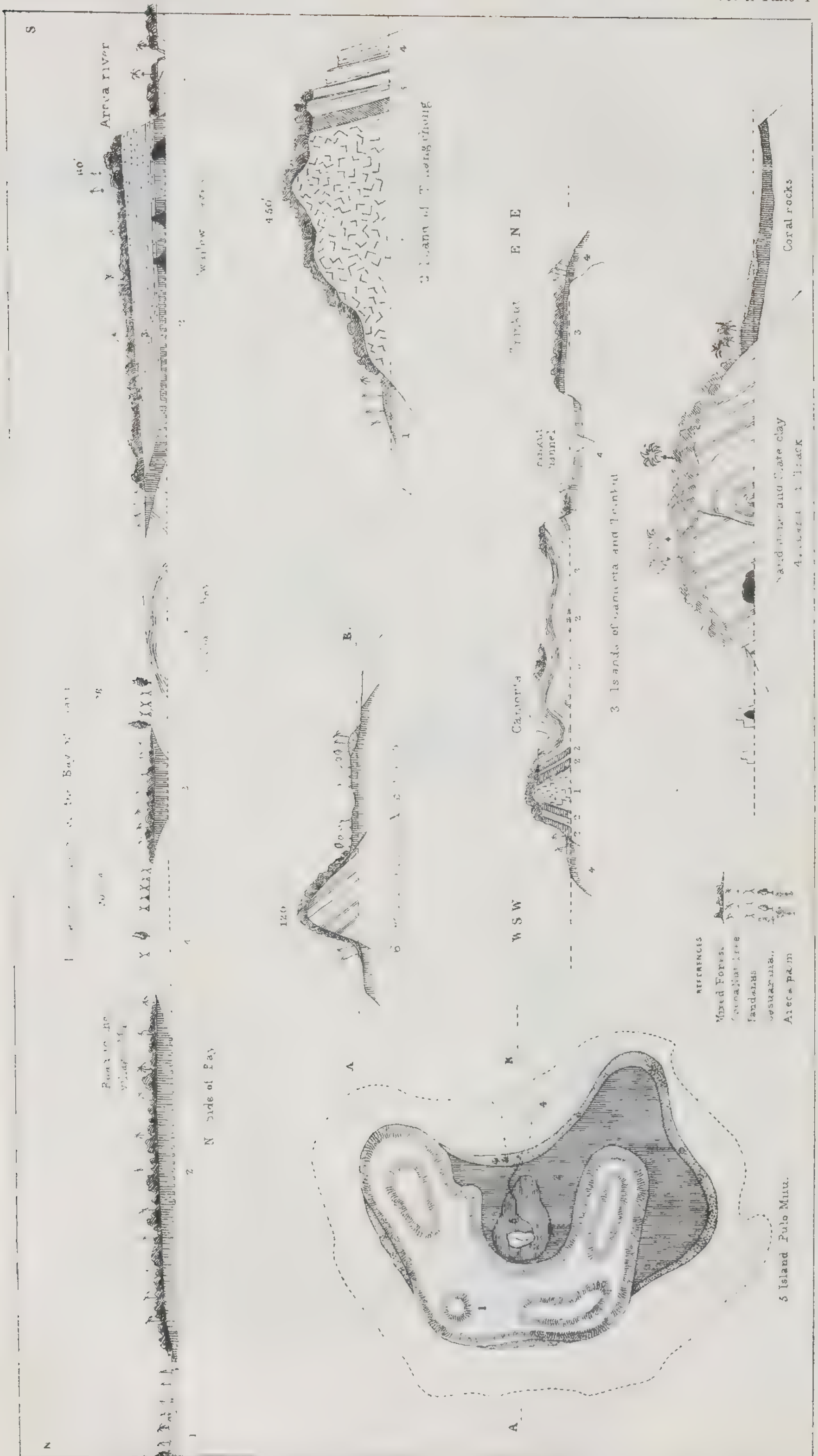
Iron used to be made in various parts of the province, but the manufacture has ceased in consequence of the facility with which Foreign iron can be obtained.

In conclusion, it remains only to be stated that several points of interest necessarily passed over in this hasty sketch have been reserved for subsequent consideration in the report to accompany the map, data for which are still being collected.

Amongst these are some facts tending to afford further proof of the association of aqueous deposits with the earliest beds of the Stratified Trap, and also indications that their highest flows or beds were not much older than the lowest Tertiary rocks, if indeed some of them were not contemporaneous.



Calcutta 1869


Arreca river
S
N side of Bay
WSW
ENE
Canoreta
3 Islands of
REFERENCES
Mixed Forest
Pandanus
Casuarina
Areca palm
5 Island Pulo Milu.
Coral rocks
N

The occurrence here of the persistent and well-marked band of laterite and its associated white clay or steatitic breccia, passing conformably upwards into the Tertiary beds, and less regularly, but still with an appearance of transition, into some of the bedded traps below, though differing from certain of the facts observed in the country north-east of Surat, may possibly modify some of the conclusions with regard to the more obscure occurrence of the same three groups, *i. e.*, the bedded traps, lateritic beds, and Tertiary rocks of Guzerat, or may, at least, confirm the impression of the volcanic activity which produced the bedded traps dating from early Tertiary times.

If, in the absence of fossils, lithological similarity be admitted as evidence, it may be possible that some of the white felspathic sandstones, considered as Upper Jurassic, overlying the Zamia-beds of Kutch, may represent some of the frequently similar looking Mahadeva or Bâgh beds of Central India and the Nerbudda Valley.

The evidence for a Jurassic age comes chiefly from the lower part of the series, which is certainly marine so far, and the occurrence therein of a band of shale containing *Zamiæ* may bear the explanation before suggested, but at present the discussion of these points is almost premature.

April, 1869.

Much interest having been excited in the history of the Nicobar Islands, which have recently been taken possession of in the name of Her Majesty the Queen of England, I have thought it desirable to print here a brief summary of all that is known regarding their geological structure. This could most effectively be done, by giving a translation of the reports of Dr. F. v. Hochstetter, who accompanied the Austrian '*Novara*' expedition as geologist. Dr. Stoliczka, long a colleague and friend of Hochstetter's, has translated this report. The geological portion is given nearly at full. The part relating to the vegetation and its connection with the soils, however interesting to those who have never seen a tropical vegetation, contains little that would be new to residents in this country; and only a few extracts are given. A few remarks on springs and temperature conclude the paper.

The geology of the Nicobars has many points of the highest interest to the Indian geologist, as bearing on the structure of the adjoining Andamans, and the continuation of the same features into Burmah and northwards, on which connection some information will be given in future numbers. T. O.

CONTRIBUTIONS *to the* GEOLOGY AND PHYSICAL GEOGRAPHY OF THE NICOBAR ISLANDS, *by* DR. F. VON HOCHSTETTER, *(translated by* DR. F. STOLICZKA, *from the "Voyage of the Austrian Frigate* NOVARA *round the world in* 1857-1859." *Geological part, 2nd vol., pp.* 83-112. *Vienna,* 1866).

The Nicobar islands (Pl. 3.) belong to an area of elevation which can be traced from the Bay of Bengal far into the southern seas. Beginning under the 18th degree north latitude in the group of the Cheduba and Reguain islands on the coast of Arracan, passing through the Andamans and Nicobars, then continuing through Java, Sumatra, and the south-western group of the Sunda islands, this line of elevation bends in an oblique S-form through New Guinea, to the north of the Australian continent, and forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie islands being possibly considered as the extreme southern end of this curve. Winding from the northern into the southern hemisphere through 70 degrees of latitude, this line, or area, is characterized as one of elevation by two phenomena, totally different in their nature, but nevertheless equally grand, and in certain respects related to each other. These phenomena are, first, the activity of the interior of the earth, showing itself in the volcanic action; and secondly, the activity of the coralline animals, disclosing itself in the formation of that kind of coral reefs which Darwin has distinguished from the barrier or lagoon reefs under the name of fringing or coast reefs.

Both phenomena, the volcanic action with its elevatory power, and the formation of coast reefs, are, in certain respects, related to each other, as has been placed beyond a doubt by Darwin's observations, although both do not appear together along all parts of this area.

In the southern extra-tropical latitudes, where coralline life does not exist on that large scale, the volcanic action is the only marked one, and equally so in tropical latitudes to the north of the equator,—where that action is locally wanting,—the peculiar formation of coral reefs must be considered as the principal argument for the continuation of this line of elevation. This is the case at the Nicobar islands.

These islands occupy a gap without volcanoes, between the volcanic range of Sumatra, and the Barren and Narcondam islands, which lie to the east of the Andamans.

Whatever may be hidden in the interior of the Nicobar islands, covered with perfectly impenetrable primeval forests and grassy plains, the occurrence of younger volcanic rocks is the least probable. Although I have found on the north side of Car-Nicobar, the northernmost of the islands, two pieces of a porous basaltic rock, the size of a man's hand, in a coarse gravel in the forest near the village Mus, and a larger angular fragment in the coral sand on the strand near the village Saui, still there is more reason to believe that these fragments were transported to the coast of Car-Nicobar in the roots of stranded trees,* or even that they were remains from the travelling bags of the Danish naturalists of the Corvette *Galathea*,—who in 1846, shortly before they landed on Car-Nicobar, visited the volcanic Barren island,—than that they came from the interior of the island. I have in vain searched for similar pieces in the stream- and river-gravels of Car-Nicobar, and I have not met with them on any of the other islands on which we landed.

On the other hand, the Nicobar islands are distinctly characterized as a portion of the chain of oceanic elevations, which began in former geological periods and still continues, by the upheaved coral banks and by the continuous formation of coral reefs, which slowly, but in the course of hundreds and thousands of years perceptibly, enlarge the territory of the islands.

The Austral-Asiatic area of elevation, above indicated in its entire extent, has in the Nicobars a mean direction to north-20°-west or from south-south-east to north-north-west, possessing a length of 118 Engl. (= 37 Ger. geogr.) miles, and a width of 16 Engl. (= 4 geogr.) miles. This direction indicates at the same time the strike of the strata on all the islands, while the dip is either towards east or west. The synclinals and anticlinals in the geological structure of the islands are thus coincident with the direction of the great geological line of elevation which connects the northern point of Sumatra with the group of the Andaman islands.

The total area of all the islands is calculated to be 33 to 34 German (geogr.) square miles (equal to about 528—544 Engl.).

1.—*Geological Formations.*

To render properly intelligible the results which will be given in the following pages, I may be permitted to make a few preliminary remarks.

It is at present extremely difficult to make any detailed geological observations on the Nicobar islands. One is limited to the sea coast, as impenetrable forests and grassy plains make the interior of the islands perfectly inaccessible and hide the rocks. On the northern smaller island, this circumstance is of less importance, because the extent of the rocks through the whole island can easily be ascertained, as soon as it is possible to observe them on two opposite sides of the coast in the same stratigraphical relation. The case is different with the southern larger islands. Sambelong or Great Nicobar has an area of 17½ geographical square miles, and is larger than all the other islands put together; it offers in the mountain ranges (rising up to 2,000 feet), and deep valleys, such a variety in the configuration of the ground, that it is impossible to suppose that what is to be seen on one or the other point at the coast should be characteristic for the whole island. The mouths of rivers being generally occupied by mangrove swamps, it is even impossible to come to any conclusions from gravels as to the rock which is to be found in the interior. But even on the coast there are great obstacles to geological investigation. Wherever the inquiring eye of the geologist observes promising cliffs, there breakers make it generally impossible to land, and where landing can be effected, we usually meet only a flat coast.

* Chamisso mentions the transport of stones in the roots of stranded trees on the Radek group, and Darwin gives a similar example from the Kieling islands. (Darwin's natural history travels, part II, p. 242).

Thus one is limited in his observations to the few points, where during low water it becomes practicable to reach from the sandy shore some rocky promontory; and even under the best circumstances I was always restricted to that part of the coast on which the frigate anchored, for no amount of promises and offers could induce the natives to undertake longer trips with their canoes, neither was it possible to obtain a boat from the frigate at my disposal. I hope that other geologists, who may in future visit these islands, will be more successful in this respect.

My observations were therefore confined to the following places:—

1. *North-western coast of Car-Nicobar.*—A low precipitous coast accessible along its entire extent. Thick clay beds, with some more solid strata of sandstone, containing *Fucoids,* are on this coast overlaid by upheaved coral banks (coral conglomerate and coral sandstone); these are in some places still in direct communication with living coast reefs.

2. *Southern Bay of Car-Nicobar.*—Flat coral ground with fringing reefs, and at the breakers banks of a recent sandstone.

3. *Novara Bay on the west coast of Tillangchong.*—Precipitously rising cliffs of serpentine and gabbro conglomerate; at the breakers' coast reefs.

4. *Channel between Camorta and Nancowry, or the Nancowry Haven.*—A deep transverse cleft through yellow clay-marls containing magnesia, alternating with beds of serpentine and gabbro traps, and pierced through by serpentine and gabbro. A long stretching coral reef formation exists in the channel, but coral ground is very limited.

5. The small islands *Trice* and *Track,* north of *Little Nicobar*; precipitously upheaved; clayey sandstone beds with imbedded pieces of bituminous brown coal; coral and conglomerate banks and fringing reefs.

6. *Pulo Milu.*—A small island on the north side of Little Nicobar, consisting of strongly raised sandstone beds, with flat coral ground, fresh water alluvium, and fringing reefs round the whole island.

7. Island *Kondul* on the north side of *Great Nicobar.*—Sandstone, sandy slates, and beds of clay-marl alternating with each other, flat coral ground of very limited extent, fresh water alluvium, and fringing reefs.

8. *A small bay on the northern coast of Great Nicobar.*—Sandstone hills, salt-and brackish-water swamps.

9. *East side of the southern bay* (Galathea Bay) *of Great Nicobar,* in which flows the Galathea river; sandstone mountains; flat coral ground, coral and conglomerate formation at the level of the breakers, fringing reefs; pebbles of bituminous coal on the strand

These places are, with the exception of Car-Nicobar, the same as were seen by the Danish geologist Dr. Rink, accompanying the expedition of the Danish Corvette *Galathea* in 1846, and were, beside many others in the Archipelago, visited by him during a stay of four months, described in a special work.*

As to scientific inquiry, I left the Nicobars quite unsatisfied in spite of the comparatively long time of one month which we spent in their waters; I know well how little my own observations increase the geological knowledge of the islands, for which we are indebted to Dr. Rink; for just the grandest objects, the islands *Terressa, Little* and *Great Nicobar* remained for me totally a *terra incognita.* But I am conscious to have done every thing that it was possible to do under the circumstances, and in this point of view the few observations I can offer must be criticised.

Car-Nicobar is a low island, the average height of which above the level of the sea amounts to about 45 feet; only two ridges, which may be from 180 to 200 feet high, rise in the interior above the forest covering nearly the whole island. The west, south, and east, coasts are flat and sandy, and the north-west and south-east monsoons accumulate upon them gradually higher and higher fragments of corals and shells, which pass over the fringing reefs surrounding the whole island. The south coast is in part swampy, only the northern or rather the north-western coast, forming the shore of the bay of Saui, is precipitous, allowing a view of the geological structure of the island; the section of this coast is given

* Die Nikobarischen Inseln, eine geographische Skizze, mit specieller Beruchsichtigung der Geognosie. Kopenhagen, 1847. (The Nicobar islands, a geographical sketch with special reference to geology).

in the sketch Pl. 4, Fig. 1.—*Eastern shore of the Bay of Saui.* 1, Loose coral and shell-sand: 2, Dead coral-banks: 3, Indurated rock-beds of dead corals and shell-sand: 4, Plastic-clay with bands of sandstone.—

The eastern shore of the bay gradually rises from north towards south up to a height of about 60 feet, and includes two small lateral bays in which massive banks of a gray clay crop out below upheaved coral banks which form the projecting corners of the cliff. It is very characteristic that the boundary of the calcareous and clay strata on the surface of the coast terrace is at the same time a sharp limit of vegetation, inasmuch as on the clayey ground the cocoa-palm is replaced by *Pandanus*, *Casuarina* and grass, forming locally quite extensive open plains. The clay deposits, without any distinct stratification, show a cubical cleavage. The prevailing color is light-gray, only single bands are darker colored, others are ferruginous, containing numerous clay-ironstone nodules. The clay is a little calcareous, effervescing with acids. In the southern lateral bay also appears between the clay beds a more solid stratum from two to three feet thick, and from its projecting part larger and smaller plates are broken off. On one of these plates I observed the impression of a large species of *Fucus (Chondrites Nikobarensis*, Hochst.) The strike of the strata is from south-south-east to north-north-west in both bays, the greatest thickness observable in the strata amounts to 20 or 30 feet. This clay deposit on the northern coast of Car-Nicobar is characterised as a marine formation by the numerous *Foraminifera* which it contains, but I did not succeed in finding any recognizable remains of *Mollusca*, except indistinct and badly preserved bivalves *(Pelecypoda)*.*

Farther towards the south, the clay beds again sink under the level of the sea, and in their place again appear coral banks, the precipitous coast becoming constantly higher, but at the same time gradually more inaccessible. On this coast the sea has washed out deep hollows, and the coral-banks are overlaid by massive banks of a white rock consisting of shell and coral sand, and being rather soft on the weathered surface. On the Areca river, in the innermost corner of the bay of Saui, the plateau of about 60 feet rapidly terminates with a fault, and the southern shore of the bay only exhibits a flat sandy strand richly overgrown with cocoa trees, being at the same time thickly populated. Judging from a few lumps in the gravel which I found on the northern as well as on the southern side, I conclude that there is somewhere in the interior of the island a gray fine-grained sandstone with little flakes of white mica and also a compact limestone *in situ*. The natives use the sandstone from the gravels as grinding stones.

Batty Malve is a small rocky island with precipitous shores all round. It rises on the south-eastern and eastern side in two terraces to about 150 feet. On the western and north-western side, it runs into a low flat cliff; judging from a distance of two or three nautical miles—we did not come nearer—the island is inaccessible. The extreme shore seemed to be covered with grass only, the interior was a low jungle, the crown of cocoa-palm being here and there visible at its margin. Only opposite Car-Nicobar can the island give an impression of a "relatively bare rock," as Steen Bille† says.—The rocks to be found on the island are most probably the same as those of Car-Nicobar.

Tillangchong, situated opposite Car-Nicobar, is a narrow mountainous island with precipitous cliffs, stretching from north-west towards south-east; it consists of two ragged mountain ranges separated by a depression of only 30 feet in depth. Where, on the south-east side, both ranges meet, a deep bay is formed, which during the north-west monsoon offers an excellent place for anchorage. The less precipitous south-western coast is accompanied by a few rocky cliffs, while the north-eastern coast is highly precipitous all along the shore. The highest hills are situated in the northern part of the island, apparently rising to an elevation of about 500 feet. Serpentine and gabbro form no doubt the great mass of the island.—Pl. 4, Fig. 2.—*South-east coast of Tillangchong.* 1, Coral-rocks; 2, Serpentine and Gabbro; 3, Breccia; 4, Sharply elevated rock-beds.—

In the small bay on the south-western coast, the Novara bay, in which the frigate was lying at anchor for a few hours, the irregular and cliffed-like shores are composed of common

* The description of the very well preserved *Foraminifera* from the above described clayey beds was undertaken by Dr. K. Schwager. His very valuable paper will be appended to this chapter of the Nicobar Islands, and for farther results I here refer to this paper.

† Captain Steen Bille was Commander of the Danish ship *Galathea*.—T. O.

serpentine, often traversed with veins of hornstone, and the same is the case with the thickly wooded mountain slopes, as far as could be observed in the small rocky beds of streams. The shore exhibited a very great variety in the color of the serpentine, jasper and hornstone pebbles: besides these, however, there were noticed also numerous pebbles of a dark green diallage rock, which must no doubt be *in situ* somewhere on the same coast at no great distance.

From the angular fragments of serpentine and other masses in the course of decomposition, a ferruginous breccia is formed at the foot of the hills, while in the breakers the serpentine gravels are being cemented by coral and shelly sand forming solid sandstone and conglomerate banks which recall the Verde-antique, (Ophicalcite). The plateau of the coast-reefs extends 2 to 300 feet from the precipitous shore into the sea. The whole of the island was covered with thick primeval forest which thrives well, even on the serpentine ground.

In passing along there were observed on the southern part of the island and on the eastern coast thin-bedded rocks with a high dip; these were in massive cliffs almost perpendicular in the south-eastern bay with a columnar structure; their true nature remained, however, unknown to me, for I was unfortunately obliged to use the telescope in place of the geological hammer.

Camorta, Trinkut, Nancowry with ***Katchall*** form the middle group of the Nicobar islands. Trinkut is situated in front of the eastern entrance of a channel between Camorta and Nancowry; it is a low island surrounded by coral reefs, and on its southern coast whitish-yellow argillaceous marls crop out. *Camorta* and *Nancowry* exhibit a greater variety of formation.—Pl. 4, Fig. 3.—*Sections of Camorta and Trinkut.* 1, Gabbro and Serpentine; 2, Breccia and tufa; 3, Clay marl with sandy beds; 4, Coral-rocks.—The channel between the two islands, the Nancowry haven, has numerous small bays and corresponds with a transverse cleft, while the Trinkut channel is a longitudinal cleft. The precipitous shores of the former offer, therefore, the most instructive geological section.

The narrow western entrance to the Nancowry channel is marked by two projecting rocks, which have been washed out by the force of the waves, making thus a natural gateway of rocks. Both cliffs rising almost perpendicularly to about 80 feet, are formed of a coarse breccia, composed of angular fragments of serpentine and gabbro* firmly cemented. I could not observe any stratification in this rock on the Camorta side; it is here in cliffs with large quadrangular blocks. On the Nancowry side, however, coarser bands alternate with finer tufa-like ones, with a strike from south-south-east to north-north-west and dipping about 85 degrees towards west. On the Camorta side, there crop out at two places below heaps of masses of rocks, which Rink very properly regarded as friction-breccias, cliffs of a more or less serpentine or gabbro-like massive rock.

Among the pebbles on the strand, I also met with numerous fragments of a reddish-brown rock traversed by white calcite veins, the rock which Rink called Eurite.

These phenomena at the western entrance to the Nancowry-haven are thus perfectly identical with those which Rink has observed at the entrance of the Ulala bay, situated only a few miles to the north; they are represented (l. c. p. 68) by Rink in a section. Further to the north the mostly bare hills on the west coast of Camorta, recalling by their external shape conical volcanic forms, attain a height of from 4 to 500 feet; they no doubt indicate the further extension of the serpentine and gabbro-rocks, which on Camorta and Nancowry are traversed from south-south-east to north-north-west by a longitudinal cleft.

In the interior of the Nancowry haven, wherever the rocks are exposed on the projecting angles, they appear to be well-bedded, whitish-yellow, clayey marls, alternating with banks of a fine-grained sandstone, with serpentine and gabbro tufas.

Most instructive in this respect is the precipitous south-eastern corner of Camorta at which the coast line bends into the Trinkut channel. The argillaceous marl formation is here well exposed in cliffs of from 30 to 80 feet high. On the southern side of the corner the transverse section of the strata can be observed, dipping at 25 to 30° towards west, while on the eastern side, parallel to the longitudinal break, the beds crop out horizontally one above the other. The argillaceous marl does not contain fossils, is of a yellowish white color,

* Gabbro is a rock composed of diallage, smaragdite or hypersthene with labradorite or saussurite, and often some other minerals in an irregular mixture

and on the perpendicular walls it was covered with inch-long, white, very thin, crystals of a silky lustre. The examination of these showed them to be sulphate of magnesia. The clay itself contains, according to Rink's analysis, besides silicate of alumina, iron-oxide and magnesia.

The whitish-yellow clay marls of Camorta and Nancowry being entirely free of lime have become famous since Professor Ehrenberg (Berl. Akad. Monatsberichte 1850, p. 476), by an examination of the samples brought by Dr. Rink, has shown that they are true *Polycistina*-marls, like those of the Barbados. Ehrenberg discovered in 1848 about 300 species, which were by Professor Forbes believed to belong to miocene (tertiary) deposits. Ehrenberg says: "Especially well developed is this material on Camorta, where, near Frederickshaven, a hill 300 feet high is covered all over with variegated *Polycistina*-clay, while the Mongkata hills on the eastern side of the island are according to Rink entirely composed of a whitish-clay resembling meerschaum; this is, according to my analysis, a nearly pure agglomerate of beautiful *Polycistina* and their fragments, beside numerous *Spongiolites*."* The species of *Polycistina* on the Nicobars are, according to Ehrenberg, the same which compose the similar marl on the Barbados, situated in nearly the same latitude; but there are also some new forms.

Near the level of the sea, the clay marls, which locally contain angular fragments of serpentine and gabbro, alternate with more solid strata of a psephitic rock, which is composed of strongly-cemented angular fragments of serpentine and gabbro, and can therefore be best designated as gabbro-tufa. It is remarkable that this rock again includes larger and smaller pieces of the clay marl. On the eastern coast, near the village Inaka (Enaca) a reddish micaceous sandstone appears between the clay marls.

Similar are the geological conditions on the northern coast of Nancowry. Between the villages Inúang and Malacca, the whitish-yellow clay marls crop out in slightly inclined strata; between Malacca and Injáong, however, lies a precipitous cliff, on which these strata rise almost perpendicular, and are gradually replaced by an accumulation of fragments of serpentine and gabbro. At the projecting corner itself, the traveller faces a precipitous cliff of about 60 feet in height, but being cracked and decomposed, the true nature of the rock is recognised with difficulty. On a fresh fracture, however, one soon observes a massive diallage rock, the laminar diallage being clearly traceable in the nearly solid mass of felspar. Narrow veins of quartz pass through the rock.

From here up to the village Injáong the strand is again flatter, and nowhere nearer than on the other side of the village high, dark-colored, rocks are a second time visible, indicating a massive rock. These are the two places which Rink also has marked on his maps as plutonic rocks.

Trice and Track.—On the north-western point of the small island Trice, highly upheaved banks of a fine-grained argillaceous sandstone of a greenish-grey color form a low precipitous shore. The same stratified rocks alternate with thin-bedded sandy slates, showing on the south-eastern coast margin of the small island Track, only a few cables length distant, the accompanying section. Pl. 4, Fig. 4. Besides a fault, the strata form a saddle and strike from south-south-east to north-north-west. In a sandstone bank I found here imbedded a rolled fragment of a bituminous coal, the same of which I met with a larger but equally rolled fragment on the strand of the island Trice. Of coal seams there was, however, no trace to be detected; what might be mistaken for them from a distance was only the shadow of softer sandstone banks deeply weathered out, or the darker color of some strata.

Pulo Milu.—A small island on the northern coast of Little Nicobar, which Dr. Rink has so excellently described in all its peculiarities, consists, in the higher parts, of a grey, fine-grained, micaceous and calcareous sandstone in massive banks. Very often spheroidal concretions are to be observed showing on the soft weathered surface like cannon balls. No trace of fossils could be found. The massive banks have thin-bedded sandy slates interstratified. The strata strike from south-south-east to north-north-west, dipping to east at an angle of 45 degrees. Dr. Rink (loc. cit, p. 50) mentions a fossil resin in the sandstone of Milu.

* The result of examination of a Nancowry specimen is figured on Plate XXXVI of Ehrenberg's 'Mikrogeologie.'

Pulo Milu was particularly instructive for me, because the dependence of the vegetation on the soil and its geological basis could be perfectly well recognised. The vegetation and the geological formation of the ground stand in the closest relation to each other, as clearly shown by the accompanying sketch plan. The sandstone hills are covered with jungle; the coral (calcareous) ground with high forest trees; the saline, calcareous, sandy ground is occupied by cocoa-palms, and in the fresh water swamp on the declivity of the hill range, which resembles in its curve a horse shoe, thrives the finest forest of *Pandanus* which we have seen on the Nicobar Islands.—Pl. 4, Fig. 5. *Plan of the island of Pulo Milu.* 1, Sandstone with bushy forest; 2, Coral conglomerate, with high tree forest; 3, Coral and shell sand, with forest of cocoa-nut trees; 4, Coast reefs; 5, Fresh water alluvium, with forest of *Pandanus*. Pl. 4, Fig. 6, *Section of same island on line A. B. Fig. 5.*

We have not visited the coast of Little Nicobar, the mountains of which rise to 1,000 feet elevation above the sea.

Kondul—between Little and Great Nicobar,—consists of a hilly ridge, $1\frac{1}{2}$ nautical miles long and $\frac{1}{2}$ mile broad; its strata strike north-north-west., and dip at 70° towards east. The western side is the precipitous one. The strata represent an alternation of more or less sandy or clayey beds. The sandstone predominates, yellowish-white, with ferruginous reddish-brown particles. The clayey beds partly consist of a greasy plastic clay, partly of a crumbling yellowish clay marl, with intercalated thin-bedded sandy slates. The only organic remains which I found were indistinct traces of *Algæ* and small rolled fragments of coal.

Great Nicobar.—What shall I report of Great Nicobar? With the exception of some sandstone hills on the northern coast, and the sandstone ranges on the eastern side of the Galathea Bay in the south, I have not seen anything. Great Nicobar, with its mountains rising up to 2,000 feet, is geologically quite a *terra incognita.*

A very remarkable earthquake, which is said to have lasted from the 31st of October to the 5th December, 1847, on the Nicobar Islands, at which time also earthquakes occurred in the middle and western part of Java, is described from the *Penang Gazette* in *Junghuhn's Java* (part II, p. 940). On this occasion fire is said to have been seen on one of the mountains of Great Nicobar.

Can the highest mountain of Great Nicobar be a volcano? Its form is that of a volcano, but as Junghuhn says that one could land on the southern coast of Java, wander about many days among sandstone and slate rocks, without obtaining through any of the phenomena even a trace of the stupendous volcanic nature of Java; in the same way there may be in the interior of Great Nicobar, rock-formations hidden, of which one does not get an idea along the coast. However, I do not attach any importance to the rumour that fire has been seen on Great Nicobar, though the description of the earthquake seems trustworthy, as I had myself occasion to observe on Kondul the mountain-slips referred to in the account.

These few observations, combined with those of Dr. Rink, give us the following, though probably still very imperfect, idea of the geological nature of the Nicobar Islands.

Among the various geological formations on the Nicobar Islands, *three* are the most important:—1, *An eruptive serpentine and gabbro formation*; 2, *Marine deposits, probably of a younger tertiary age, consisting of sandstone, slates, clay marls and plastic clay*; 3, *Recent coral reef formations.*

The serpentine and gabbro formation of the Nicobars is characteristically of an eruptive nature. The tertiary sandstones, slates and clay-marls appear forcibly broken through; their strata are partly inclined, partly bent in flat, parallel, wave-like, undulations. These rocks are accompanied by coarser and finer breccias composed of angular fragments of these same rocks, and they can partly be regarded as friction-breccias, partly as sedimentary tufas in which beds of an argillaceous marl are interstratified. The eruption of these plutonic masses appears, therefore, to fall in a time when the formation of the marine deposits was partially completed, partially still in progress. They broke through, on lines of fracture of which the principal strike from south-south-east to north-north-west agrees with the longitudinal extension of the islands. On the middle islands, the serpentine and gabbro attain their greatest development; on Tillangchong, Terressa, Bompoka, Camorta and Nancowry they form bare hill-ranges of from 2,500 feet elevation, and their configuration often marvellously

resembles those of younger volcanic formations. The elevatory power has, however, acted most strongly on the southern islands, and has here upheaved sandstones and slates probably to heights of 1,500 to 2,000 feet above the level of the sea; on the low northern islands the same power was, on the contrary, weakest.

With regard to the sedimentary deposits, I may state that Rink called the argillaceous deposits of the northern islands "older alluvium," and the sandstones and slates of the southern islands "brown-coal formation." In separating them from each other, he considers the former as being derived from plutonic rocks through chemical and mechanical decomposition, and as only of a local character. According to this the archipelago of the Nicobars is divided by him into two geologically different groups,—an opinion with which I cannot agree.

The clays and clay-marl formations of the northern islands, Car-Nicobar, Teressa, Bompoka, Camorta, Trinkut, Nancowry, and the sandstones and slates of the southern islands, Katchall, Little and Great Nicobar, appear to be only petrographically different products of one and the same period of deposition. There are at the same time very few materials from which the age of the marine formations could be determined, as the only fossil remains which have been found in their strata are fragments of *drift wood* changed to brown coal, plant impressions resembling *Fucoids, Foraminifera and Polycistinæ*. But all these remains indicate more or less distinctly a young tertiary age.

The same conclusions are derived from a comparison with the geological conditions of those islands which lie on the same line of elevation as the Nicobars; I refer especially to Sumatra and Java.

I have not the least doubt that the clay-marl and sandstone formation has its perfect analogue among the tertiary deposits of Java, which I had myself the opportunity of studying and comparing in their distribution and lithological character. These became first known through the late Fr. Junghuhn, whose researches on the physical geography of Java are of such merit.

According to Junghuhn, one-fifth of the surface ground of Java is alluvial soil. This is especially prevalent on the northern side of the island, extending from the coast inwards either one, or sometimes five to ten English miles; one-fifth of the island consists of volcanic cones, and their immediate vicinity where the lower rocks are covered up by volcanic products. These conical hills chiefly occupy the interior of the island, sometimes in a double range stretching from west to east; while three-fifths of the area are occupied by tertiary rocks. Either in flat protuberances or in clod-like elevations, these tertiary rocks surround the volcanic range always on two sides, on the southern as well as on the northern. On the northern side, the less highly upheaved tertiary strata underlie the alluvium, and therefore occupy on the surface a small area. In an unequally greater degree, the tertiary deposits are developed on the southern side of the volcano, both as regards height and horizontal extent. They are mostly visible split in clods (schollen) which always rise higher towards one side,—the north, or towards the volcanoes,—and are at their highest edge upheaved to 2, 3 and even to 4 thousand feet. It is also principally on the southern side that plutonic rocks occur in the neptunian deposits of Java, which are occasionally only represented by narrow and sharply defined veins, without any influence upon the structure and configuration of the surface; sometimes, however, they form small hill ranges or isolated hills, similar to the serpentines and gabbros of the Nicobar islands.

According to the reports of the Dutch Mining Engineer, Huguenin,* a repetition of the geological formations of the Nicobars appears to be met with in the Tjiletuk Bay (the southern lateral bay of the Wynkoop Bay on the southern coast of Java). The prevalent formations here are sandstone-conglomerate and highly developed greenstone-breccias, besides plutonic rocks of the greenstone group. From specimens which I had an opportunity of seeing in the local collection at Beutenzorg, I found that these plutonic rocks are serpentines, gabbros and aphanites, exactly similar to those of the Nicobars. Equally identical appears to be the chalk-white clay-marl in the middle portion of Bantan, and the fine white marls in the southern portion of Tjidamar, mentioned by Junghuhn (loc. cit., p. 13), with those occurring on the Nicobar islands.

* Natuurkundig Tijdschrift voor Nederlandsch Indie, Theil XII, p. 110, 1856.

At the time of my stay in Java (1858), and from all I could find described, as well as from my own observation, I came to the conclusion that in the tertiary deposits of Java two principal groups can be distinguished, setting aside the limestone formation, the proper place of which in the system of Javanese deposits is as yet doubtful:* 1. *A lower coal-bearing group:* numerous workable seams of brown coal are imbedded in quartzose non-calcareous sandstone and slate-clay with silicified stems of trees; marine shells are very rare, or absent. To this I referred the coal seams discovered by Junghuhn in the south-western part of Java, as also the coal formation on the Kapuas river in West Borneo, and the extensive coal districts in Southern and Eastern Borneo, finally the coal of Benkulen (Bencoolen) on Sumatra, and numerous other similar deposits scattered over the Indian Archipelago. 2. *An upper group without coal:* a clay and sandstone formation with plastic clay-slates, argillaceous marls, calcareous sandstone, trachytic tufas, breccias and conglomerates, rich in marine shells, fossil plants, fossil resin, but merely with nests of coal in place of coal seams.

Reasons, which I have given elsewhere,† have induced me to regard this complex group of strata as probably of Eocene age. This opinion may even now stand as regards the lower group, while as regards the upper group, I gladly accept the opinion of my friend Baron v. Richthofen, and the conclusions derived by H. M. Jenkins,‡ from which these fossiliferous deposits appear to be younger Miocene.

I suspect that to this upper Miocene group correspond the tertiary deposits of the Nicobars, although fossils confirming this suggestion have yet to be discovered. It is also beyond doubt that these deposits are not wanting on Sumatra, in certain respects a connecting link between Java and the Nicobars. Junghuhn (loc. cit., p. 8) justly remarks: "The tertiary formation appears to have a sub-marine extent over the whole of the Indian Archipelago, because wherever within this Archipelago the earth's surface rises above the level of the sea, this neptunian formation is observable. I know this for certain as regards Northern Sumatra, where the tertiaries are especially found in the Batta districts (Batta ländern). With the exception of the trachytic island Dungus Nasi all the islands in the Bay of Tapanuli (situated exactly in the prolongation of the Nicobars), besides the adjoining low shores of Sumatra, and partially also the mountains near Tuka, are composed of more or less upheaved sandstone strata, containing, though sometimes rarely, tertiary shells." Thus it appears to be principally on the southern coast of Java and the south-west coast of Sumatra that we find a repetition of the geological conditions of the Nicobars.

The commencement of the eruptive formation is in Java inaugurated by serpentine, gabbro, massive rocks resembling diorite (greenstone trachytes as in Hungary); more or less typical trachytic rocks follow, and the grand volcanic eruption extending up to the present time from the termination of the enormous eruptive phenomena in the Indian Archipelago. At the same time it appears that the eruptive line has been shifted slowly, on Java from south to north, and on Sumatra from south-west to north-east, so that this line would strike east as regards the Nicobar group in the same longitude in which east of the Andamans it reappears on the volcanic Barren Island and Narcondam.

The young tertiary age of the serpentine and gabbro eruptions on the Nicobars and Java has its perfect analogue in the eruptions of the same rocks in Central Italy, which, according to Signor Perazzi, in Turin, and Prof. Savi, are partly Eocene, partly Miocene, and which, on account of their copper ores, are of importance to the miner.

The third principal formation of the Nicobars are coral formations, belonging to the most recent or the present period. Coral banks of great thickness are found on Car-Nicobar, Bompoka and several other islands; they consist partly of a compact coral limestone, partly of a coral or shell conglomerate, upheaved up to 30 and 40 feet above the present level of the sea; on all the islands, the original area is to be observed enlarged by coral-land, which is only separated by the higher sand dunes along the shore, from the still continuing formation of the coral reefs surrounding all the islands in the character of fringing reefs. Although these raised coral banks are a decided evidence, in favor of the long continued

* According to Junghuhn this limestone is the youngest of all the formations, and is always to be found only in superficial banks.

† Reports on the doings of the mining engineers in Netherlands India (Jahrbuch der k. k. geol. Reichsanstalt, Wien, 1858, p. 277).

‡ Quart. Jour. Geol. Soc., London, Feb., 1864.—F. Baron v. Richthofen, Zeitschrift der deutschen geol. Gesellschaft. Bd. 14, p. 327.

upheaval of the islands,—that in connection with the eruption of the serpentines and gabbros,—the formation of the flat coral-land elevated only a few feet above the level of the sea can, on the other hand, be explained by the accumulation of coral fragments, of sand and shells by the waves and breakers on the shallow surface of the fringing reefs. A detailed description of the peculiarities of the Nicobar coral reefs and of the formation of the low coral-land has been already given by Rink. (loc. cit., p. 88, &c.).

II.—*On the occurrence of coal and other useful rocks and minerals on the Nicobar Islands.*

The question regarding coal was the principal point of inquiry during the first expedition to the Nicobars, which was undertaken in 1845 by the Danish Consul *Mackey* of Calcutta, the Englishman *Lewis* and the two Danes *Busch* and *Löwert.*

The solution of this question was a second time the problem undertaken by Dr. Rink, as geologist with the royal Danish Corvette "Galathea." The order of the day No. 5, which contained the instructions and directions for the survey and exploration of the Nicobar islands on the part of the scientific expedition of His Majesty's Frigate "Novara," made the reply to this question my duty also.* The facts on this point are as follows:—

The results of the first expedition were confined to the discovery of single pieces of coal on the strand of the southern islands. Dr. Rink found several localities of coal on different places of Little Nicobar, Trice, Milu and Kondul. "These localities at which coal occurred proved, however, everywhere to be isolated masses varying from one to two inches in thickness." The incorrect (as already stated) designation of "brown coal formation" for the sandstones and slates of the southern island might have been the cause of misunderstanding; but Rink himself (loc. cit., p. 53) expressed his results thus:—"There appears nothing found on the Nicobar islands which would correspond with the coal formations of South-Eastern Asia. The coal localities were met with here and there without any order either in sandstone or in slate, and appear to me therefore to be derived from driftwood which was deposited with the clay and sand. I nowhere found anything which could indicate an accumulation of plants in basin-like depressions, in which the plant would be growing *in situ* and through which the surrounding masses of clay would be impregnated with organic ingredients and mixed with portions of plants. The question, therefore, still remains pending whether those brown coals occur in considerable quantity, as the quantity and size of the collected pebbles would seem to indicate."

I also did not succeed farther than finding single fragments of brown coal. The first fragments were met with on the strand of the small island Trice; it was a brown coal with conchoidal fracture, but still with distinct structure of the wood. The pieces were all rolled, and the largest—5-inches long, 4-inches broad and 2-inches thick—was bored by *Pholadidæ.* I do not doubt that these pieces were derived from the beds of the sandstone or slate of Trice; but on the opposite island Track, I was fortunate to knock out of the sandstone, *in situ*, a small fragment of coal also rolled. Exactly in the same way I also found small fragments of brown coal on Kondul and on the south side of Great Nicobar, partly on the strand, partly on the sandstone or slate rock, and it is certain that these pieces occur all through the group of islands. The condition of all the brown coal fragments met with tends to show that they were only singly imbedded driftwood pieces, which were changed to coal, not that they belonged to large coal seams through the destruction of which they have come into younger strata. Only on the strand of Pulo Milu have I obtained pebbles of true coal with laminated structure, such as is only to be found in seams. It is, however, much more probable that these pieces of coal came from the steamer "Ganges" accompanying the "Galathea" in 1846, and stopping for some time about Pulo Milu, than that they were derived from coal seams on the Nicobars. I therefore entirely agree with Rink's opinion, that so far as it is possible to make observations nothing speaks in favor of the existence of true coal basins on the Nicobars, and that the occurrence of workable coal is not probable. However the area of Great and Little Nicobar is large enough to hide under the thick primeval forest formations of which no trace

* This instruction runs:—According to the report of the naturalists of the Danish expedition, coal and probably also precious metals occur. As far as this may be verified, samples in sufficient quantity ought to be taken equally so in case of metals being found. In general it is however to be reported, as regards geological conditions, how far conclusions can be drawn from the existing rocks as to the occurrence of useful minerals, &c. Of the rivers and springs, the temperature should be measured, &c., &c.

may be observed along the coast. Until the interior of these islands has been examined, the question regarding coal on the Nicobars cannot be answered in any other way than it was by the first expedition.

Equally unfavorable must be the opinion regarding the occurrence of ores or other useful minerals. Nothing of the kind has yet been found on the Nicobars. Gold and useful minerals are partially rich on islands and along coasts which, viewed geologically, belong to the same area of elevation as the Nicobars, as I have already pointed out. The natives who long ago observed those fragments of coal, who use glass pearls, silver fragments, &c., as ornaments, who know the plants and animals of their islands pretty well, and who have for all more common phenomena, for all useful products of the animal and vegetable kingdom special names, these inhabitants have as yet found among the rocks of their islands nothing that they would be able to make use of for ornament or other useful purposes. The only traces of ore which I found were those of iron pyrites and copper pyrites, finely disseminated through dioritic and serpentine-like rocks. The possibility of the occurrence of copper ores in the eruptive formation cannot be denied; however, no discovery has as yet been made which would indicate it. On the other hand, the islands are rich in useful building materials. The sandstones of the southern island must give excellent working stones; the plastic clays of the northern islands could no doubt be equally well worked into bricks or into pottery; the natives of Chowry make large pots of it. Finally lime is offered by the coral reefs in inexhaustible quantity along the coasts of all the islands.

III.—*The soil and its vegetation.*

[Only brief extracts of this section are given.]

Dr. Hochstetter states that vegetation in its original state always indicates the character of the soil, provided the atmospheric conditions are the same. This is, however, on the Nicobars, highly the case. 'Neither the difference in the latitude from the most northern to the most southern islands ($2\frac{1}{2}$ degrees), nor the difference of the absolute elevation (the highest hills on Great Nicobar only attain about 2,000 feet above the sea), is large enough to produce on the single islands, or parts of them, such a difference in the climatal conditions, that on it alone an altered character of vegetation should depend. Rocks, soil and vegetation are, therefore, on the Nicobars in such a degree related to each other, that the areas marked on a map as indicating various rocks would almost coincide with those indicating the varieties of vegetation. Unfortunately the sketching out of such maps for the larger inaccessible islands is impossible; to indicate it I can only attempt a representation of the small island Milu (Pl. 4, Fig 5.) and the north-western bay of Little Nicobar.'

'The results of these observations may be seen in the following tabular view :—

Geological character of the underlying rock.	Character of soil.	Respective character of vegetation.
1. Salt and brackish swamp, damp marine alluvium.	Swampy ground not capable of cultivation.	Mangrove-forest.
2. Coral conglomerate and coral sand, dry marine alluvium.	Fertile calcareous soil; principal constituents, carbonate and phosphate of lime.	Cocoa-palm forest.
3. Coral conglomerate and coral sand beside dry freshwater alluvium.	Fertile calcareous sandy soil.	Large forest trees.
4. Freshwater swamp and damp freshwater alluvium.	Swampy ground, capable of being cultivated.	Pandanus forest.
5. Plastic clay, magnesian clay, marls and partially serpentine.	Not fertile clayey soil; principal constituents, silicate of alumina and silicate of magnesia.	Grassy plains.
6. Sandstone, slate, gabbro, dry river alluvium.	Loose clayey, sandy soil, rich in alkalies and lime, very fertile.	Jungle (the true primeval forest).

'*The Mangrove forest.*—Several deep channels, rich in fishes and navigable by the canoes of the natives, occasionally extend in serpentine turns through these mangrove swamps. One meets not uncommonly at the end of such channels in a hidden locality villages of the natives, as for instance, on Trinkut the pirates' village Dschanoba.' (Janoba).

'The brackish-water alluvium, the ground of the *Rhizophori* and *Cerithia*, must, therefore be considered as a soil perfectly unfit for cultivation. It occupies only a small area as compared with that of the islands, but it is nevertheless of a mischievous importance. For it can justly be said that the Nicobars owe their unhealthy climate principally to these brackish-water swamps, as they occasionally extend for miles from the mouths of the rivers into the interior. In these swampy districts, the change of the fresh to salt water causes a decay of the organisms, which can only exist in the former, the reverse takes place in salt water changing to fresh water. The ebb exposes large areas, and decomposition of the organic life takes place, filling the air with most poisonous miasmas.'

Dr. Hochstetter says that he especially had opportunity of studying these marked changes on a grand scale on the northern coast of Great Nicobar (west of the Ganges harbour). On the other hand, the coral land appears to be fertile, capable of cultivation, and healthy at the same time, and the dry marine and freshwater alluvium, to which on the sea coast belong the cocoa-palm forest, and further inland extending to the back of the hills, a beautiful forest of various kinds of large trees. This is the ground which the natives of these islands have selected for their abode, finding here all the necessaries of life.

The cocoa-palm forest is described by Dr. Hochstetter as the picture of life, and he thinks that if the cocoa-palms had not been there, the islands would have been probably uninhabited up to this time. He further states that, taking the number of the inhabitants of all the islands to be 5,000, there would be about five and a half millions of nuts required for annual use. The annual export of cocoa-nuts can further be estimated as about ten millions, for Car-Nicobar alone exports between two and three millions. This gives fifteen and sixteen millions of cocoa-nuts to meet the annual demand. On the northern islands, the cocoa-palms occupy comparatively a larger area, while on the southern islands, especially on Great Nicobar, they are nearly altogether wanting. The northern islands are, therefore, the most thickly inhabited, and the cocoa-palms are there divided as property, but on the southern islands they appear to be the free, common, goods of all.

'The Nicobarese not only lives on, but also in, the cocoa-palm forest, having selected for himself not only the most comfortable place for his hut, but being on the dry coral ground, exposed to the current of the wind, also the most healthy situation.'

'*The high forest.*—This is chiefly composed of large trees with rich foliage.' Several valuable timber trees, and others, useful on account of their fruits, are here mentioned.

'The finest high forest I saw on the southern coast of Car-Nicobar.'

'*The Pandanus forest*, in which this remarkable tree suppresses all other vegetation, except a few *Areca-* and *Rotang*-palms, occurs only on the swampy fresh-water alluvium along the course of rivers and streams, especially near the sea where the rivers form more or less permanent basins. Here it is *Pandanus Milore*, the largest kind of *Pandanus*, which forms the forests. I believe that what we saw of the Pandanus forest on Pulo Milu, was one of the most peculiar pictures of tropical vegetation seen during the whole of our journey.'

'The *Pandanus* is not cultivated on the Nicobars; it is most flourishing in a wild state, and is, after the cocoa-palm, the most important plant for the natives as regards food: it is the truly characteristic plant of the Nicobar islands.

'*Grassy plains.*—If one has succeeded in marching from the flat coral-land through the high and *Pandanus* forests, he generally reaches the foot of hills, rising on the larger southern islands, on Great and Little Nicobar to a height of 1,000 to 2,000 feet above the sea, but on the northern islands they are not above 500-600 feet. This hilly land certainly occupies $\frac{3}{11}$ to $\frac{1}{4}$ of the whole area. It is composed of rocks of the gabbro and serpentine formation, and of the clayey and sandy tertiary beds formerly noticed. The eruptive rocks are comparatively of small extent. Where felspathic gabbro forms the ground, this being produced by the decomposition of the rocks may be said to be fertile, it is covered with thick forest, but even the serpentine island Tillang-chong has a flourishing primeval forest. On the other hand, a remarkable difference is perceptible in the vegetation of the tertiary ground'

'The hills of the northern islands are to a great extent only covered with grass, those of the southern, however, chiefly with a thick forest vegetation. This distinction rests upon an essential difference in the composition of the ground. The hills of the northern islands consist of a sterile argillaceous soil, those of the southern islands, on the contrary, of a fertile calcareous, sandy-argillaceous soil.'

'Where the most favorable tropical climate could produce nothing else, but stiff and dry Lalang-grass *(Imperata)*, and rough Cyperaceæ *(Scleria, Cyperus, Diplaceum)*, surely there nature has clearly enough left the stamp of sterility, yet just between such grassy hills, which from a distance look so homely resembling fields of corn, have the colonists on the Nancowry channel built their houses and gardens. The grass grows now high enough above their burial grounds; the breakers play with the bricks with which they built the houses; gardens and fields, every path has disappeared. On Car-Nicobar I saw these grassy plains partially cut down, because the natives use the grass for thatching their houses, and on Kamorta large strips were in flame.'

The grass vegetation, says Rink (loc. cit., p. 136), which to the greatest extent covers these islands, is, in the valleys at the base of the hills, very thick and high; it becomes however, higher up thinner and shorter. On the places which are sufficiently damp many soft grasses may occur rich in juice; but on the tops of hills, where the dry magnesian claystone locally penetrates through the scanty layers of soil, and is also partially covered with a coarse ferruginous sand, while the showers of rain carry all the finer particles which may be produced by decomposition into the valleys, there, as a rule, only dry and rough siliceous *Gramineæ* and *Cyperaceæ* are to be met with.

The area which may, therefore, in future be successfully cultivated is that of the southern islands, composed of sandstone and slate, producing a fertile argillaceous sandy soil. On Little and Great Nicobar with the small islands Pulo Milu and Kondul, the hilly land may be estimated at nearly two-thirds of the total area. These islands are therefore in point of colonization the most important, and a comparison with Ceylon and Pulo Penang shows what could prosper where now impenetrable primeval forest covers the whole surface.

'*Primeval forest.*—This is of great extent, and the coast inhabitants of Great Nicobar tell of the existence of a wild tribe, forest-men, ("jungle men"), with long hair, inhabiting small huts or trees and living upon honey, roots and game. But no European eye has yet sighted these forest-people.' Dr. Hochstetter describes in vivid language the evermore forest-clad parts of Great Nicobar, which were visited by some of the party along the deeply indented water courses and ravines.

IV.—Springs, Streams and Rivers.

The annual rainfall of the Nicobars is unknown. But very likely it is considerable; I think 100 inches is an exaggeration, because the two seasons, usually distinguished,—the dry one during the north-east monsoons between November and March, and the wet one during the south-west monsoons between April and October,—are not so strictly separated on these islands as on the neighbouring continent, and according to present experience showers are also not rare during the dry season. The driest month of the year may be March. We had, during our stay on and round the islands, in this month only three times rather heavy showers of rain. In April they become more frequent, until in May and June the south-west monsoon rolled constant and heavy clouds over the islands.

If, therefore, peculiar geological conditions do not facilitate a rapid flowing off of the rain, the islands cannot have in general a want of water. And of this we could convince ourselves, inasmuch as the end of the dry season was unfavorable for the quantity of water in streams and rivers. Even the smallest islands, like Pulo Milu and Kondul, though their small streams hardly had any water flowing, still had an abundance of fresh water in the numerous basin-like depressions of their beds. From the forest-clad heights of Tillangchong still rippled out everywhere spring water. The numerous streams and rivers of the southern large and woody islands, Little and Great Nicobar, possess abundance of water all the year round. But the northern island, as far as the argillaceous beds extend, appears to be deficient in water; this specially is the case on Nancowry, Camorta, Trinkut, and probably also on Terressa and Bompoka. I found the small streams on Nancowry and Camorta, leading into the Nancowry haven, perfectly dried

up. The natives only drank cocoanut-water, and they probably obtain the fresh water which they require for domestic purposes, &c., like the boiling of Melori, from the fresh water swamps, which are locally to be met with in ravines. Of wells, except that made near the village Malacca on Nancowry and which is now half in ruin, I saw nothing. Car-Nicobar, however, though also composed of argillaceous strata, as the abovementioned islands, has no want of good drinking water, because the large coral land raised from 8 to 12 feet above the level of the sea, permits the digging of those remarkable wells, the fresh water of which falls and rises with the ebb and tide. The explanation of this rare phenomenon does not rest in the filtering of the seawater by the coral-sand, but is rather the fact that the lighter rainwater floats on the heavier seawater, and the porous coral rock only prevents the mixing of the two. I have seen several such reservoirs on Car-Nicobar near the villages Mus and Saui, they were all dug from 8 to 10 feet through the coral mass nearly to the level of the sea at its highest flood, and contained good drinking water. Besides this, a river flows into the Northern Bay of Car-Nicobar, which we named Areca River from the luxuriously growing Areca-palms on its banks; this river is navigable with flat boats two miles upwards, and near the small rapids which one meets it also offers good drinking water, containing only a small portion of calcareous constituents in solution.

I have not become acquainted with any mineral or warm springs. The clay-marl rocks of the Nancowry haven are, however, seen covered with an inch-thick incrustation of sulphate of magnesia (epsom salts) in fine fibres with a silky lustre; this indicates a quantity of sulphate of magnesia in the clay-marls, and by digging holes in them, epsom salt waters may probably be obtained, such as is the case with the bitter sandy-marls near Bilin in Bohemia.

V.—Observations on the temperature.

As we had, according to our instructions, to measure the temperature of rivers and springs, and as this task fell to my lot, as far as opportunity offered itself, I would put upon record here the few observations in this respect, besides a few remarks on the temperature.

a.—Temperature of the different waters.

1. 23rd February, on Car-Nicobar, water in the well near the village Saui in 8 feet depth in perfect shade ... ... 25·7C.
2. 27th February, on Car-Nicobar, Areca river in the shade of the primeval forest ... 25·0C.
3. 4th March, on Tillangchong, western side, a spring in the shade of primeval forest 25·5C.
4. 4th March, on Tillangchong, another spring .. .. 26·0C.
5. 8th March, on Nancowry, old well of the Moravian Brothers near the village Malacca, water in 8 feet depth in shadow ... ... 25·7,C.

If it were permitted to make from these few observations a conclusion upon the mean of the annual temperature of the Nicobars, this mean would be 25·58C. (=78·04 Fahrt.)

I have also measured the temperature of several other wells and streams, but as their water was temporarily exposed to the sun, very different results were obtained, as for instance:

on Car-Nicobar	
24th February, well near Mus, water in 3 feet depth	27·0C.
25th „ a stream between Mus and Saui	27·8C.
26th „ river near Saui	29·0C.
on Camorta	
9th March, two streams with muddy stagnant water	27·0C.
on Pulo Milu	
18th March, stagnant stream water	26·5C.

b.—Temperatures of the soil.

To obtain further materials for the determination of the mean annual temperature I made a few observations on the temperature of the soil, and these gave the following results:—

8th March, on Nancowry near the village Inuang, the thermometer, after it had been exposed in a permanently shaded place for 6 hours, showed, when buried in 3½ feet depth underground ... ... 25·7,C.
20th March, on Kondul, also in 3½ feet after 6 hours ... ... 25·3,C.

These two observations give, as did those made in water, an annual mean of ... ... 25·5,C. (=77·9 Fahrt.)

This result is smaller than the records known up to the present, but these also do not rest upon sufficiently decisive observations. Rink, who, during a stay on the islands between January and May 1846, never saw the thermometer under 25°C. and never above 33°C. in perfect shade, believes 28°C. to be the most probable mean.

According to Johnston's Physical Atlas, the line indicating the temperature of the sea surface of 30·5C passes just across the group of islands, the annual isothermal being 26·1C., with the January isothermal of 25·0C, and the July isothermal of 27·2C.

As regards the monthly means, we obtain from the observations of the Danish Corvette *Galathea* every four hours:

for January 1846 ... ... 28·2C.
„ February „ ... ... 28·6C.

According to the hourly observations on board of the Frigate *Novara* the mean is—

For the days 23rd,—28th February 1858 ... ... 27·2C.
„ „ „ 1st,—26th March ... ... 27·5C.
} mean 27·25C.

With this agrees pretty fairly the soil temperature which I measured at a depth of one foot.

On the 26th February near Saui ... ... 27·7C.
„ „ 20th March on Kondul ... ... 27·0C.
„ „ 26th „ on Great Nicobar ... ... 27·0C.
} mean 27·26C.

Finally, with regard to the daily means, they will be found for the time of our stay on the Nicobars in the observations recorded on board of the vessel. It occurred to me when on Car-Nicobar to see whether the temperature of the water of young cocoanuts, when freshly cut down from a tree standing in shadow, would not indicate approximately the mean daily temperature. I found on the 26th February, in two nuts, a temperature 27·2C. and 27·4C., as a mean 27·3C. The journal kept on board of the Frigate gives for the same day, as mean, also 27·3C.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1869. [November.

On the beds containing Silicified Wood in Eastern Prome, British Burmah, by Wm. Theobald, Junr., Esq., Geological Survey of India.

No fact relating to the geology of Pegu is better known than the abundance of silicified wood occurring in the valley of the Irawadi, but as no detailed account has hitherto been published of the beds from which this fossil wood has been derived, it is my intention in the present notice to give such a sketch of them as will show their most salient points of interest and facilitate the recognition of the group elsewhere, where its occurrence might from its mineral character be overlooked and its beds confounded with other and more recent deposits. At the same time I shall, as much as possible, restrict myself to the area of Eastern Prome and to the fossil-wood group proper, only incidentally alluding to the great series of beds with which it is intimately connected, and on which it rests, as each group has a marked facies of its own, is generally, as a rule, easily recognizable and characterised by entirely different organic remains, though the balance of evidence as yet tends to prove a passage from one to the other and an undisturbed sequence in the beds composing them. The fossil-wood group, too, is the smaller and, as regards its organic remains, the simpler of the two, and can therefore be treated by itself more conveniently than in connexion with the lower, from which the organic remains require much additional study and comparison with living species, for which very imperfect facilities at present exist.

The most familiar form in which fossil-wood occurs in the Irawadi valley is that of well rolled and polished pieces of from one to six inches in length, distributed through the coarse shingle which underlies the ordinary alluvial clay of the province and is freely exposed in the bed of the Irawadi at a variety of places, as, for instance, under the station of Thaiet-mio and on the opposite bank under the deserted fort of Miadé. Opposite Prome also a great thickness of this gravel, less coarse than at Miadé, but equally well supplied with well worn and rounded fragments of fossil-wood, occurs, fully 30 feet thick, and rising to a height of about 60 feet above the present flood-level of the Irawadi.*

Besides the ordinarily sized pebbles of fossil-wood, there occur in the gravels towards the frontier, as close to Thaiet-mio, for instance, well rounded logs of silicified wood, some two or three feet or more in length. These, of course, have never travelled very far from their original site, and we accordingly find the parent beds of this quasi-ubiquitous fossil-wood in force but a very few miles from the river, whilst irrefragible evidence presents itself of the former extension of these beds over a much larger area than now occupied by them even as far south as Rangoon in the chips of logs of fossil-wood of a size too great for distant transport, either resting on some lower member of the group, or encased in more recent deposits, the detritus of the beds which originally enveloped them, and with no greater change of position than that wrought by the mere action of gravity during the long process of denudation going on around them.

It is not easy very precisely to describe the distribution of this group without reference to a map, but in Eastern Prome the area it occupies may be taken at something less than

* The coarse character of this gravel or shingle, the well rounded and polished condition of its ingredients, consisting of the hardest silicious rock, and the somewhat mixed size of the pebbles, seem to me greatly in favor of the marine origin of this gravel at a period antecedent to the formation of the present river valley, when the sea was wearing away the shaly rising beds I am now about to describe, though I cannot so much as guess at the source of those silicious rocks of which most of the pebbles consist, so different are they from anything now found in the neighbourhood, or I might say province.

700 square miles, of which not more than a bare fifth or sixth is covered by the highest sandy bed with which the fossil trees are associated, and which from its incoherent character has everywhere suffered to the greatest extent from the action of denudation. There can be no doubt that the entire group formerly extended as an uninterrupted deposit far below the latitude of Rangoon, though the highest member of the group with its associated fossil-trunks does not extend down now in force nearer than 130 miles or thereabouts to that town, or not south of the Tounguyo nulla. The exact termination to the south, however, of this fossil-wood bed is rendered very obscure, by its merging, so to speak, in the debris which has resulted from the waste of the group, and beneath which it sinks and is lost sight of. That it formerly extended much further south is rendered certain (and perhaps the occurrence, *in situ*, of patches beneath the newer accumulations at the present time is also indicated) by the occurrence of large pieces scattered about within the area of the detrital beds above mentioned, of a size such as to preclude the idea of transport from a distance; as, for instance, between the Okhan and Thonsay streams, where a log of not less than four feet in length is embedded in a mass of confused detritus fully 65 miles south of the spot I have assumed as the southerly limit of the group containing the fossil wood *in situ*. Smaller pieces of fossil wood are found much nearer Rangoon and in cuttings in the neighbourhood. These pieces on my first visit to Rangoon, and before I entertained any suspicion of the connexion of the beds at Rangoon and those containing the silicified wood, I was inclined to regard as brought to the spot by human agency, as the Burmese are fond of surrounding their religious buildings with posts of this wood "Engin chouk," but I am now convinced that such is not the case, but that the pieces in question are derived either from the wasted and missing upper beds or from the lower ones of the group still remaining, which, as I shall show, contain the same fossil-wood, though sparingly and never in the same sized pieces as the upper or emphatically *the* fossil-wood bed of the province. Thus the fossil-wood in the Prome district occurs in two distinct formations and under very different conditions, *viz.*, in the form of entire trunks *in situ* or fragmentary pieces, but little rolled, and in well worn or polished pieces, some of large size, but more frequently as pebbles, which form a conspicuous ingredient in the recent gravels.

Below I give, in descending order, a table of the main divisions into which the miocene beds east of the Irawadi may be divided, the upper three of which constitute the fossil-wood group of which I am now treating:—

MIOCENE.

(Descending).

Fossil-wood group.

(a).—Sand—in parts gravelly and conglomeratic—characterised by the profusion of concretions of peroxide of iron associated with it; fossils, trunks of silicified exogenous wood and locally mammalian bones. In the subordinate beds of conglomerate, rolled fragments of wood as above, silicified, (that is, mineralized subsequently to their entombment), mammalian and reptilian bones and teeth of cartilaginous fish.

(b).—Fine silty clay with a few small pebbles mixed with sand in strings here and there the whole very fine and homogeneous and devoid of fossils.

(c).—A mixed assemblage of shales, sand, and conglomerates, the last very subordinate, partaking much of the characters of beds *a—b*; a little of the concretionary peroxide of iron. Fossils, rolled wood silicified; mammalian and reptilian bones and cartilaginous fish teeth. Towards the base, the beds contain marine shells, and pass into those of the next group.

Pegu Group.

(d).—An enormous succession of sandstones and shales of unknown thickness and not usually fossiliferous. Particular beds, however, contain fossils in profusion:

(*e. g.*, *d*-1.—Hard sandstone with corals *(Cladocera)*.

d-2.—Blue Kama clay, highly fossiliferous.

d-3.—*Cytherea Promensis* bed or Prome sandstone,

and numerous others which cannot be specified till their fossil contents have been more especially examined).

(a).—This bed which we may fairly suppose to have been once co-extensive with the rest of the group is now greatly diminished in area by denudation, which its mineral character even more perhaps than its position at the top of the same has tended to encourage, so that even within the area where it is at present best preserved it by no means constitutes the entire surface, being everywhere deeply scored through to the underlying beds below. The surface is everywhere protected by a gravelly layer composed of small quartz pebbles and ferruginous concretions derived from pebbly strings and irregular courses of conglomerate dispersed through the sand, which readily washing away leaves the residual layer in question at top; to the protection afforded by which against further waste, the existence of what still remains of this incoherent bed is largely due. This surface layer is of variable thickness, its development being, to some extent, a measure of the denudation this group has undergone. On the surface and impacted in it at different depths where it is very thick lie logs of silicified wood of all sizes from a foot or so to trunks of 40 and 50 feet, not entire, but jointed up into pieces of various lengths through spontaneous fracture, probably brought about by their own weight, and irregular subsidence during the removal of the friable matrix wherein they were originally encased. Though, as a rule, these large logs occur as described in a gravelly debris, they sometimes occur relatively to the incoherent sand so as to leave no doubt of its being the bed wherein they were originally deposited, and on which they may be sometimes seen apparently *in situ*, as between Thanat-ua and Kiungee, and not only in this bed but in the beds beneath it, the same fossil-wood occurs, though in smaller pieces, and much less abundantly. The larger logs are quite unrolled, but the smaller pieces are often rounded by transport, though never to the extent seen in the pieces of fossil-wood contained in the recent gravels. When this sand rises into hills, the sides are invariably steep, and not unfrequently scarped, exposing a clean vertical section of sand with its crust of gravel at top. This sand weathers into curious pinnacles wherever an isolated stone, shell, stick, leaf, or other foreign body has afforded shelter from the direct impact of rain, and the incoherent rock all round washing away eventually leaves the protecting substance perched on a slender pinnacle of sand, which recalls the similar phenomenon of the "earth-pillars of Botten" figured by Sir C. Lyell in the 10th Edition of his "Principles."

In color this sand is greyish, very fine and uniform, and with only a certain admixture of impalpable argillaceous matter forming, where exposed to traffic, a fine dust, or, in the beds of streams where the argillaceous portion has been removed by water, a clean silver sand very fatiguing to travel over. Though the sand I am describing unquestionably contains silicified wood, yet it seems probable from the great abundance of large trees strewed over the surface, that they existed more plentifully in that topmost portion which has almost disappeared through denudation leaving only these bulky memorials behind it, than elsewhere. The structure of the wood has been to a considerable extent obliterated by decay before its mineralization was effected, and all that can be definitely said of it is that the wood is exogenous and not a conifer. I have remarked but one species in Prome, though the Burmese, from trivial distinctions in color and weathering, affect to recognise the modern Enjin *(Hopea suava)* and the Thiya *(Shorea obtusa)*, an identification of course quite illusory. This wood nowhere exhibits any traces of marine action as might have been anticipated had it floated about till water-logged in a brackish or purely salt estuary, and hence it may be inferred with considerable probability that it floated about in a fresh-water sea, or chain of lakes fed by a sluggish stream, till it sank where it became ultimately silicified. It must at the same time be remembered that the wood found in beds containing marine fossils is also free from perforations, but these are small pieces, much rolled prior to their entombment and probably under conditions on some sub-marine bank unfavorable to the presence of either *Pholas* or *Teredo*. In some pieces of fossil wood I have noticed minute tubular cavities (perforations?) about ·02 or less in diameter, which might have been produced by some insect whilst the trunk was still standing, but such cases are rare. Associated with this sand, and forming sometimes irregular beds in it, or more frequently lenticular courses, now thickening, now thinning out, occur some hard sandstones, sometimes very fine grained, at others a pebbly grit, or even coarse conglomerate. No regular position in the sand can be assigned to these subordinate layers, but the fine hard sandstone often occupies a high position in the deposit, whilst a coarse conglomerate is not unfrequently met with towards its base. Both sandstone and conglomerate are usually richly charged with shark's teeth of small size *(Lamna)*, the conglomerate being usually ossiferous as

well, though throughout the deposit the occurrence of bones is irregular, capricious, and local.

A good section displaying the relation of these grit-courses to the less coherent rock around them, is seen in the hills about three miles east of Shuebandor, or about fifteen miles east of Alán-mio. The hills are here steeply cut in the bed I am describing, the surface being covered with the usual gravel, with abundance of silicified wood and ferruginous concretions, the former completely blocking many of the deep gullies cut on the hill side. Strewed about here may likewise be seen numerous lustrous fragments of iron slag, from the native furnaces once scattered over these hills. The sand here presents its usual incoherent, typical character, but a compact sandstone, passing into a coarse grit in patches, is somewhat freely developed in irregular lenticular courses in it. On the surface of the incoherent sand at this spot, and evidently weathered out of it, I picked up a fragment of the lower jaw of a deer, and from the immediate vicinity I collected mammalian bones, mostly ill preserved and fragmentary, shark vertebræ and teeth, and chelonian plates *(Colossochelys* and two species of *Emys)*. In the great slabs of grit lying about amidst the debris of the wasting sand which enveloped them shark's teeth were plentiful, accompanying mammalian bones and fragments of wood, many of which had been perfectly rounded by attrition before they were embedded. These pieces of wood are, however, not common. Another locality where bones are still more abundant is one-half mile north-east of Talok, or fourteen miles north-east of Thaiet-mio on the east bank of a stream not marked on the map. Bones are here far from scarce, but friable and ill preserved. They occur both in the incoherent sand and also in the coarse grit and conglomerate associated with it, together with shark's teeth and small pieces of wood. At this spot there is a good deal of coarse conglomerate, and in accordance with the indications afforded by these coarser beds we find the bones of a larger size, and many of these much rolled and abraded before they were finally embedded. Here I got a fragment of the lower jaw of an elephant, together with fragmentary portions of the limb bones of that animal, all imperfect either from original violence or subsequent decay, the former cause certainly operating in some instances.

I may here remark that the bones found in this group (within the area I am now concerned with) are not all in the same mineral condition. The majority are somewhat imperfectly mineralized and consequently decay very readily when bared to the atmosphere by the wasting of the surrounding rock, and this I am convinced is the reason of so few bones being found on the surface, even in spots where the rock is seen to contain them somewhat plentifully. A few fragments may here and there remain, but most of the bones noticed by me were so tender, that it was clear that a short exposure to atmospheric action would reduce them to crumbling masses, which would break up and leave scarcely a trace behind them. A bone is, however, here and there found in the water courses well mineralized and calculated to defy atmospheric action, but the scarcity of these fragments attests that such is not the usual condition of bones in these beds. That these well mineralized bones are derived from the same beds as the more friable ones is undeniable. The best mineralized bone perhaps met with was the part of a deer's jaw above mentioned, and this most certainly was derived from the soft incoherent sand whereon I picked it up. The astragalus of a ruminant *(Cervine?)* found also by me during a former season, was in like manner an isolated example of well preserved bone, though being found in a small stream its parent bed was not demonstrable. In Upper Burmah well mineralized bones are probably more common to judge by those which have been at various times collected there, and the difference is merely the result of different conditions at the time of their deposition, such as we might expect to prevail, and depending probably on the irregular access or supply of silica in solution. That the supply of this silica must have been at some period abundant is testified by the enormous amount of silicified trunks everywhere met with, but the horizon of these is certainly higher than that at which the bones in question occur, and although small pieces of silicified wood occur commingled with the bones, it does not therefore follow that the same abundant effusion of silica took place at the time of their deposition as subsequently occurred when whole forests were silicified, and this I should be inclined to regard as the true explanation of this condition of *most* of the bones in this sand, *viz.*, an insufficient supply of silica in solution.

As a rule, it is not, however, in the sand but in the coarser and more conglomeratic beds that the bones seem mostly to occur, of which a good instance is seen midway between Omouk and Lema, some 19 miles east-south-east from Thaiet-mio. Here a great bed of

conglomerate is seen dipping 30° south-east in which I noticed the tusk of a small elephant, but too friable to be extracted from its hard matrix, together with other bones, all in a poor state, and more or less injured by rolling about on a coarse shingle before their final consolidation.

Next to the presence of silicified wood, a remarkable development of concretionary peroxide of iron seems to characterise the sand I am describing. The ore occurs occasionally as a thin band, up to perhaps a thickness of three inches, breaking up or jointing into rhomboidal concretionary masses of different sizes and shapes. More usually the ore occurs in the form of variously shaped concretions from one to four inches in length, though occasionally even larger. These concretions are found in both the sand and conglomerate, to which last when numerously developed they impart a peculiar varnished look, which might sometimes be almost styled (but for the technicality of the term) viscous or slaggy. The more usual shape of these concretions is flattish oval or amygdaloidal, but they occur spherical, cuboidal, cylindrical, with both flat and hemispherical ends, discoidal and any intermediate form, but always symmetrically proportioned, and the result of a segregative action or process in the clayey and ferruginous components of the bed when in a plastic condition. Of whatever shape however, their structure is extremely uniform, consisting of an external crust of concentric layers of brown hæmatite surrounding a kernel of pure white or yellowish clay, lying loose and shrunken in the interior.

Externally these nodular concretions are roughened from the adhesion of the sand enveloping them, but this rough crust scales off readily, leaving their surface perfectly smooth. Internally they often present a blistered appearance from the mammillary crystallization of Limonite which lines them, becoming on exposure to the atmosphere and rain lustrous and varnished. Where the bed has been of too harsh a character to permit the regular segregation of the ore, it is found lining sinuous cavities in the coarse matrix, leaving flat, approximating walls, evidently produced by shrinkage, which gives such portions a very peculiar aspect and one which simulates a viscous condition. In some places even a botryoidal structure is induced where the rock is less coarse.*

The thickness of this upper sand cannot be closely estimated, but 40 feet is probably more than the average thickness of what now remains of it.

(b).—Below the last described sand occurs a deposit of very uniform character composed of pale silty clay which passes upwards into the overlying sand. This silty clay is very fine, thin bedded and homogeneous, with merely a few strings of sand here and there, and an occasional small pebble in the sand. It is everywhere seen at the base of the last bed into which it seems to pass, though their respective characters constitute a good means of demarcation between them. It is entirely devoid, as far as observation goes, of organic remains. A good section of this silty clay is seen south of Thanat-ua, between Alán-mio and Kiungalé, but the bed presents no special point of interest.

It is also largely exposed in section $1\frac{3}{4}$ miles east of Talok on ascending out of the stream (previously noticed as unmarked in the map), but it merely presents the same uniform character and absence of fossils, which distinguish it elsewhere. Where the upper sands have been completely denuded so as to leave exposed a large area of this bed, an undulating country is the result, possessing a marked character. The surface of the country does not there greatly differ in appearance from that seen within the area of the alluvium, and it would not

* Under the Burmese rule this ore was extensively smelted, but no furnaces are now anywhere at work in the district. Remains of furnaces which were merely rectangular kilns, cut in the firm alluvial clay of some steep bank, which gave easy access at top for replenishing ore and fuel, and below for withdrawing the products, are numerous about Shuebandor, Kiungalé, and Yebor, together with slag-heaps, sometimes of no inconsiderable dimensions. Throughout the area of these upper sands, however, slag may be found here and there scattered about, as the iron-workers shifted their scene of operations from spot to spot, wherever charcoal and ore was for the time most plentiful. The works must have in many cases been conducted in the dry season only, as the hearths of some furnaces still standing open into the beds of streams which during rain would certainly have found an entrance to them. The blowing apparatus was probably the effective *vertical cylinder* bellows formed of large bamboos still in use in the district by blacksmiths, but the oldest inhabitant could give me no particulars of the manufacture, as none of the class of iron-smelters now remain in the district. The introduction of English iron and steel has doubtless been the main cause of the abolition of this branch of industry, aided by the harsh and injurious system of the Burmese officials during the early struggles with the British, but in some places it was alleged that the iron-workers had fled the country to avoid being forcibly transported to Calcutta to make iron for the terrible foreigners. This may seem very absurd, but those who know the ingrained credulity and ignorance of Asiatics will be inclined to give some weight to the reason stated, though it is probable that this fear, strongly as it may once have operated, is no longer felt, though the state of the market and the price of iron now ruling in Pegu prevents the resuscitation of the trade.

be easy in a limited space to discriminate the clay in question from the ordinary alluvial clay of the valley. Where, however, freely exposed, it presents much the appearance of a 'regur,' save in color, which is a pale yellowish-gray, quite devoid of any tinge of red which the alluvial clay generally possesses, and equally so of the dusky carbonaceous hue of a regur. From some peculiarity in its composition or hygrometric qualities it in dry weather opens out in great cracks, and is always covered with a sparse crop of stunted grass in separate tufts, and a tree jungle of a peculiar aspect from the dwarfed character of the trees composing it, present among which are the Toukkian *(Terminalia macrocarpa)*, Te, (*Diospyros*, sp.), and the "Shábin" of the Burmese *(Phyllanthus emblica)*.* The country around Laidi comprising the doab between the Pade and Myo-hla streams is composed of this clay with sparing remnants here and there of the upper sands. It is largely exposed, too, in the broad valley about Lepaláh (Let-pan-hla) and between that village and Chouk-soung ("stone fang"). Towards the mouth of the Myo-hla stream near Toukkian-daing, (Htouk-kyun-deing,) this clay forms the open country and is dug for making pottery. It might here be readily mistaken for the alluvial clay of the valley, but for the occurrence here and there strewed over it of small pieces of silicified wood derived from the denuded sands which once covered it. The thickness of this bed I cannot estimate, but I should not place it under 40 feet; how much more cannot be determined.

(c).—Below the last described clay, a group of beds occurs of rather varied character, resembling, to some extent, the beds both above and below it. It contains, though sparingly, the same description of fossil wood as the sands at the top of the group, and some of its beds present characters very similar to portions of those beds; whilst towards its base, it appears to pass insensibly into the lower group characterised by marine fossils. It is, however, generally very devoid of organic remains, though, as a convenient lower horizon to it, I have taken a sandstone which is generally recognisable where the junction is clear, by a few organic remains not very well preserved, among which a coral *(Cladocora)* is most characteristic, which we may regard as the highest member of the lower group.

A section of these beds is seen in the Kini-choung (Kyeeneech) above Mogoung, which may be taken as illustrating their general character, and some portions so resemble the ossiferous sands and gravels of the upper beds that I searched confidently, though in vain, among them for like fossils.

(Descending).

Pebbly sandstone ... ... seen, about ...	50	0
Pale silty shale	3	6
Very false-bedded pebbly sandstone	16	0
Harsh sandstone, rather irregular	0	1
Compact yellowish silt with a central band of kidney-shaped nodules 1 to 2 feet in diameter	2	0
Gravelly sand	0	2
Yellow pebbly sandstone	3	0
Pebbly conglomerate, loose and gravelly	(a few feet).	
	74	9

This section, though not a thick one, will illustrate the general character of the upper portion of this division *(c)*. The silty shale much resembles the shale in division *b*, whilst the sands equally recall the uppermost sands, *(a.)* Close on the horizon of the above section

* The clay above described and the sandy beds of the same group, respectively, offer good instances of the connection of particular soils with particular kinds of vegetation. So generally does this hold good in Pegu that in some instances it affords a good empirical criterion of the geological formation beneath. In the area of the fossil-wood sands, the most prominent tree is the Eng *(Dipterocarpus grandiflora)*, and this tree so commonly affects a sandy soil that the Burmese call such soils, whether within the limits of the fossil-wood sand proper or the zone of detrital accumulations skirting the hills, "Engdaing," or the tract of the Eng tree, and though, of course, Eng trees are found on other descriptions of soil, yet it is on this sandy belt that the Eng flourishes most vigorously from probably being there less competed with by other trees, well fitted as it for a sandy soil. The "Thiya" *(Shorea obtusa*, Wall,) the "Kanyin" *(Dipterocarpus alata*, Wall,) and the "Engyin" *(Hopea suava*, Wall,) equally affect the sandy "Engdaing," though not in sufficient numbers to characterize the forest. On the other hand, these trees abhor the clay described above and are most miserably dwarfed on it. The Toukkian *(Terminalia macrocarpa)*, though dwarfed, seems to answer best on this clay, but from some cause or other it does not seem favorable to vegetation. I think this must be due rather to its hygrometric properties, than to any injurious ingredient in it, and that if artificially irrigated, it would give better promise to the cultivator than the densely wooded sands to which it offers so unpleasant a contrast.

Bamboos are not usually much developed on the Engdaing, and a striking demarcation is not unfrequently seen where the Engdaing meets the boundary of the older beds on which bamboos flourish with great luxuriance. The Burmese are fully alive to this fact, and if an enquiry is made regarding a village, say, if it stand within the Engdaing, will answer it negatively, "it is among the bamboos," an expression quite equivalent in their minds to saying it is *not* on the Engdaing where bamboos are rare and never are the characteristic vegetation.

must probably be placed the ossiferous beds, at the top of the river reach above Talohmhor (Keng-yua in map), yellowish sands pebbly at top and passing up into rather soft conglomeratic sandstone containing bones, both mammalian and chelonian, shark's teeth and vertebræ, fossil-wood and rolled fragments of oysters and other shells.

A small but instructive section is also seen of these beds in the Myouk Naweng, a little below Thambyagon (Tham-bya-ga-gon), where pale silty shales are seen supporting a great thickness of rusty incoherent sand traversed by thin layers of shale and a coarse quartzose conglomerate with clay galls and cavernous hollows incrusted with a layer of the brown hæmatite, as seen in some sandy beds of the upper division *(a)*. In this conglomerate I found mammalian bones, shark's teeth, and a small log of fossil-wood about two feet long of very similar character, though less completely mineralized than that found so abundantly in bed *a*. No other fossils were discernible here, nor, as a rule, throughout this division, though towards its base, sandstones come in containing marine shells and corals, though neither plentifully nor well preserved. These marine beds, however, are naturally more connected with the great group which follows immediately below the present, and which nowhere contains the fossil-wood so characteristic of the present group.

It only remains to add a few words on the very close restriction to the eastward of fossil wood after leaving the area of the fossil-wood group. Nowhere within the area occupied by this group is fossil wood, in pieces of the largest dimensions, more liberally distributed than along the eastern margin of the deposit along which it is everywhere found abundantly, but directly the boundary of the group is passed there is an almost complete absence of fossil wood, even in moderate sized pieces. A very close and careful search in some of the larger nullas may result in finding a piece here and there for some few miles from the boundary, but that is all, and the question at once presents itself,—has this fossil-wood sand extended formerly across the ranges to the eastward and to the Sittang Valley, or was its extension in that direction limited by a boundary somewhat corresponding in its general direction with the present boundary of the group? Without any detailed knowledge of the extent of the group on the eastern side of the Pegu range, we know the single fact that this fossil-wood group occurs in the Sittang Valley, and this and the presumed conformity of it with the lower group which constitutes the bulk of the intervening ranges of hills, would strongly lead us to regard the group as having once stretched uninterruptedly from the valley of the Irawadi across that of the Sittang, or over the entire country bounded to west and east, respectively, by the Arakan and Poung Loung chains. That this must have been the case with the great bulk of miocene rocks so largely developed in this part of the Irawadi Valley is certain, but one argument, though a negative one, is, I think, sufficient to make us pause before accepting the idea of a continuous extension of the fossil-wood bed over the same area as those of the group below it. This argument is the absence which I have alluded to of fossil wood for a distance not far short of 50 miles, that is, throughout the entire breadth of country occupied by the precipitous hills and tortuous streams of the Pegu range. When we reflect on the large size of some of the silicified trunks which may be said to strew the country along the eastern boundary of this group in Eastern Prome, and the abrupt cessation of any save the veriest traces thereof, and these but for a short distance from the boundary, and consider also the imperishable character of much of this fossil wood as evinced by its abundance in the hard and well worn gravels of the Irawadi Valley, we are irresistibly led to question the former extension of this fossil-wood bed across a belt of country wherein it has left no traces. The evidence is about as forcible as negative evidence can be. Additional weight is also given to it by the fact, that its admission presents no difficulties, but quite harmonises with the process which the geological history of the district seems to indicate as having occurred. We have only to suppose that the deposition of the vast series of miocene rocks developed in Pegu proceeded uniformly (during, possibly, a synchronous elevation, in a gradual manner, of the ocean bed) till the entire series, save the topmost members, had been deposited. Lacustrine conditions we may now presume to have supervened over portions at least of so large an area, and the elevation of the Pegu range of hills commencing about this time would cause the first land to appear on a low belt of country occupying in its general arrangement the present line of the Pegu range. In other words, the deposition of the uppermost beds of the group and notably of the fossil-wood sands would be arrested along a line of country not greatly differing from the present boundary of the group. The elevation of the Pegu range and its corresponding disturbance of the adjoining strata certainly continued

down to a period subsequent to the final deposition of the fossil-wood group, though from the mineral character of the upper beds, any movements they have been subjected to are with difficulty determined, and these movements may have, to some extent, interfered with the effect of a *coup d'œil*, but from several points of elevated ground beyond the area of the fossil-wood beds, I have been struck by the manner in which those beds were spread out; on a lower level, in a fashion strongly suggestive of their accumulation under lacustrine conditions along a stretch of elevated country almost coincident with the present boundary. This is notably the case at the extreme north of the district near the British boundary above Teybin and Bilugon, and is also to be remarked elsewhere, though the forest is so dense that it is rarely one is able to get a glimpse of any large extent of country. Had it been otherwise than here supposed, it would be extremely hard to understand how the imperishable testimony of fossil-wood logs and fragments had been so completely removed from the hilly tract, where as a matter of fact they are wanting. They are certainly the hardest bodies met with, and having held their own among the quartzose rocks which comprise the bulk of the Irawadi gravels, must, *a fortiori*, have no less successfully withstood the destructive action of denudation amidst the softer miocene beds which alone are met with in the Pegu ranges. I need not, however, dilate more on this subject, which will be readily enough cleared up when the geology of those regions above the present British frontier comes to be carefully examined into which these fossil woods extend, and wherein they seem to be more largely developed than within British territory.

MINERAL PRODUCE OF INDIA.

Towards the close of the year 1868, I solicited from the Commissioner of Kumaon (and some other officers) information as to the quantity and value of the minerals raised and brought to market within their jurisdiction. Such local operations, where minerals are raised solely for local use, and in reality are never exported, or, only in very small quantities, even transported from one district to another, taken separately, are of small importance, but when aggregated for the country at large, they represent an amount and value which must be very considerable. And these small local mining operations can only become known by the assistance of the local officers. To Colonel H. Ramsay, C. B., Commissioner of Kumaon, I am indebted for the returns now given for *Kumaon* and *Gurhwal*. The information has been collected, under his orders, by Mr. Lawder, Civil Divisional Engineer, Kumaon. Mr. Lawder was for several years one of the office staff of the Geological Survey, and possessed, therefore, a general knowledge of the subject referred to him, and has evidently devoted himself with zeal to the collection and preparation of information.

I was, I confess, surprised at the quantities stated to be raised and the extent of the mineral industry. Viewed merely as a source of employment of labour, these returns show the equivalent of the continuous labour during *every day in the year* of no less than 154 persons, and yet the effect is scarcely felt beyond the narrow limits of the province itself, excepting in so far as this local supply obviates the necessity for imports of materials from elsewhere.

MINERALOGICAL STATISTICS OF KUMAON DIVISION, collected under instructions from THE COMMISSIONER, COLONEL H. RAMSAY, C. B., by A. W. LAWDER, ESQ., Civil Divisional Engineer.

My endeavours to collect reliable memoranda of the mineral resources of Kumaon have not been so successful in their result as I could have wished. The entire absence of reliable native information, and the general unwillingness exhibited by the inhabitants to speak at all on the matter, arising from the fear that any knowledge they might communicate would perhaps eventually be the cause of increased rental demand or of the appropriation by the Government of the land in which the minerals occurred, have presented many difficulties. The information obtained from the Bhoteeas was given with great reluctance.

Owing also to my having but little surplus time to devote to the full elucidation of the subject, the memoranda supplied here are doubtless somewhat imperfect and incomplete; my duties, although carrying me to all parts of the Kumaon district, confine me (with some exceptions) more particularly to the roads, and I have probably repeatedly passed by old mines, or places rich in minerals, in utter ignorance as to their existence, not to mention other places remote from any frequented thoroughfare.

In the following notes I am indebted to reports already published for much information.

The principal economic products in the Kumaon Division are the following: gold; copper; lead; iron; arsenic; sulphur; alum; lignite; bitumen; limestones; flags; slates, &c., &c.

DETAIL OF LOCALITIES.

Kumaon District.

COPPER.—Ores of this metal are found at Rai in Gungoli, Síra Barabísí, Kharai, Kemokhét (each bank of Luddya river), Geewar, &c., &c.

Rai.—This mine is the principal one in the Puttí. The ore is chiefly pyrites, and occurs in a matrix of steatitic and talcose schist. I visited these mines in the winter of 1868-69, and found the mines closed up by a landslip, and the entrances full of water. The ore is extracted by means of drifts slightly inclining upwards to allow for drainage, as appears to be the mode most generally adopted throughout the hills. A specimen of ore which I found on the spot seemed rich. I also discovered slight traces of copper pyrites in quartzite near Gunai in Athagaon Puttí.

Síra Barabísí.—Síra is noted for its copper mine. Dolomitic and talcose rocks form the gangue. The ore is a mixture of copper and iron pyrites.

Kharai.—Goul is the principal mine. The ore is worked in the same manner as at Rai. Steatite and limestone are the neighbouring rocks, the former being the matrix principally.

Kemokhét.—Copper is found in small quantity on the east bank of the Luddya river in Kali Kumaon. I have seen no specimen of the ore.

Geewar.—There is a small mine of copper in this Puttí.

At Gurung and Chinkakolly there are mines which have been closed for some time; also at Beler and Shore.

IRON.—Iron is found in Dhuniakote, Agar, Geewar, Kutolí, Ramgurh, Tullí Rao, Chowgurka, &c., &c.

Dhuniakote.—There are the remains of some mines or burrows just opposite the staging bungalow on the left bank of the Khyrna river. The ore is hæmatite, occurring in irregular masses in quartzite. The rocks in the neighbourhood are more or less impregnated with oxide of iron. These mines are now unused.

There is also a mine south of Semulkha in this Puttí, and another in Utchakote, both now unworked.

Agar.—This Puttí is very rich in iron ore, almost every village having its mine. The ore seems to be a brown hæmatite. It occurs here generally in beds or clefts, and sometimes in irregular masses. The rocks in the vicinity are silicious. Only a few of these mines are now worked to any extent.

Geewar.—Iron occurs in quantity in the neighbourhood of the villages Khetsari, Maelchour, Tilwara, Simulkhét, Gudí, and Burlgaon. I can give no opinion as to the kind of ore, having no specimens.

Kutolí.—At Suyalgurh there is some iron ore which is not at present worked to any extent.

Ramgurh.—There are several mines in this Puttí, some largely worked.

Munglalékh.—This mine in Tullí Rao Puttí is highly esteemed for the quality of its ore, which is raised in quantity.

Chaugurka.—The ores of iron are plentiful in this Puttí, and are worked in some places.

At Jhirratolí in Darún the ore is magnetic.

Dechouree and Khúrpatal.—There is not, I believe, any ore, being at present worked by the Kumaon Ironworks Company.

GRAPHITE.—This mineral crops out at Kaleemut hill to the north of Almorah in the Jagésur range, and on the spur of Baninee Devee, facing Almorah on the Lohughat road.

Gurhwal District.

GOLD: Sona River.—This stream rises in the lower ranges of hills, and joins the Ramgunga river in Puttí Dhún. Its sands yield gold, and the bed of the Ramgunga below the junction is auriferous. The washing is not very profitable, scarcely averaging 4 annas a day to each workman.

Taluka Chandí.—The sands of the Ganges running through Chandí contain gold, but the profit arising from the washing is not greater than in the Sona river.

COPPER: Dewalgurh.—The Dhanpur and Dhobrí mines yielded largely in former times, but of late years operations have not been so vigorously carried on, owing to the intricacy of the workings, and the idea prevailing among the miners that very little ore remains in the mines. The ores are principally copper pyrites, and grey or vitreous copper ore, with the red oxide and green carbonate in smaller quantities. The matrix is calcareous. Galena is associated with the copper ore.

Nagpúr.—There are several mines here none of which appear to be at present worked.

LEAD: Dhanpur; Tacheeda.—These mines do not seem to be extensively carried on. The ore is galena, and the matrix principally of silex, with varying proportions of felspar and calcspar.

There are some lead mines at Ghertee in the snowy range between Milum and Niti which have been long since deserted, also at Rallum, Bainskum on banks of the Goree river, and Baidlee Baghir.

IRON: Tullí Chandpoor.—This ore is probably a hæmatite with a little magnetic iron. It has a slight repelling action upon the needle.

Tullí Kalíphat.—This specimen resembles specular iron ore.

Mullí Dussolí.—The specimens are highly magnetic and rich in ore.

Tulla Chandpúr, Rajbúnga.—This hæmatite ore is largely worked.

Nagpúr.—This ore gives no definite result with the ordinary rough tests. It may possibly be a carbonate of iron.

Lohba.—Here a rich hæmatite is raised in quantity.

Mulla Nagpúr.—The ore is most probably hæmatite.

Painu.—This ore is brittle and hard, and possesses the iron black colour and metallic lustre of magnetic iron, but the specimens of it failed to affect the compass in the manner characteristic of that ore. It may possibly on analysis be found to contain manganese, and if so, it will be an interesting mineralogical discovery.

Iriakote.—It is difficult to say what form of ore this is. Its streak fails to convey a definite idea of its composition. It would appear to be an hydrous form of sesquioxide of iron.

Pokrí.—These mines have been reported on by several officers.

SULPHUR.—This mineral is found both in Kumaon and Gurhwal. In the former district at Moonsyaree, in the northern parts of the district, and there are also some sulphureous springs, as that at Nynee Tal. In Gurhwal it is found in the range of hills to the north of the Pindur river within a couple of marches of Nundpriag; also at Mulla Nagpúr and Mulli Dussolí, but is not now collected to any extent.

ARSENIC.—Yellow arsenic (*Hurital*) is found in the northern parts of the district near Moonsyaree. Only small quantities are brought down to the Bagésur Fair by the Bhooteas.

LIGNITE.—Indications of lignite appear near Raneebagh, close to Huldwaní, and in the streams of the sub-Himalayas north of Nujíbabad. They do not give promise of any workable fuel, and judging from the experience obtained in other parts of the hills, it is questionable whether any lignite deposits will ever be discovered of such extent that they will repay the cost of opening them up.

An analysis of a specimen of the Raníbagh lignite gave—

Carbon	60·0
Volatile matter	36·4
Ash	3·6

The percentage of ash 3·6 contrasts favorably with that of the ordinary Indian coal raised in Bengal. The ash is colored by the presence of iron.

BITUMEN or mineral resin (*Salajit**) occurs near the summit of many mountains where it exudes from crevices in the rocks.

In the neighbourhood of Kotegaon, Gowarseo, south of Paoree, it is seen near the top of large cliffs, and is worked by natives by means of a scaffolding suspended from the summit. I am unable to state the amount of it extracted. It is generally used as a medicine and exported to the plains. Medicine from *Salajit* is also prepared in Gunguli in Kumaon, but I have been unable to ascertain from whence the mineral is originally obtained.

LIMESTONE.—The Kumaon hills are prolific in limestones, occurring both in immense masses, exhibiting various shades of color and structure, and as local Tufa deposits.

In the newer geological formations of the lower hills it occurs sometimes as a light colored rock, and sometimes as the cementing material in conglomerate beds and very frequently as Tufa deposited by local springs and streams. The process of deposition is most active during the monsoon rains, and in nearly all the springs emanating from limestone rocks, the waters are highly charged with calcareous matter.

These tufaceous deposits occur less frequently in the higher ranges, but there the blue hard limestones generally containing silex, and other hard varieties, prevail, forming well defined beds, and in many instances they are the predominant rocks of some of the larger hill runs. Small blocks of very pure black limestones are sometimes to be met with, and I have picked up some small nodules of kunkur in the Luddya river.

The principal material utilized by the natives of this district is Tufa, it being more easily burnt and prepared, and more suitable to the kutcha kilns in ordinary use. Where it has in its composition a little iron it seems to yield a strong mortar.

The localities in which lime is manufactured are very numerous, the most important being Naini Tal and Jeolí for use in the neighbourhood.

In the Kharai range, half-way between Bagésur and Almorah, from which the latter station is almost wholly supplied. At Chitailí, in the hills north of Dwara Hat; at Simulkha, Baital Ghat, and Dekolí, in the Kosí valley, for consumption in the works in progress in the new military station at Raníkhét, and on the new cart-road from thence to Ramnagar. There is also lime, somewhat silicious, in Agar Puttí, in the Retha Gâr range, Athagaon, and in almost all the hills in Gunguli. At Ramésur it skirts the road for miles.

It also occurs near Khyrna on the Almorah road, at Mulwa Tal, and in Geewar, &c.

ROOFING SLATES, &c.—Roofing flags are very plentiful in the district of Kumaon, and are generally micaceous or chloritic.

At Chitailí near Dwara Hat there are some beds of imperfectly metamorphosed clay slate, the planes of cleavage seeming to occur almost in the same lines with the bedding. The quarry was formerly used to some purpose, but owing to the neglect of former owners, it has been for years filled up with debris, so that I was unable to observe the beds properly.

Clay slate occurs also in the neighbourhood of Naini Tal, but the cleavage is imperfectly developed. There are a couple of quarries on the banks of the Ramgunga in Sult Puttí.

BUILDING STONES.—Almost everywhere in the district within easy reach good building stone is to be had. At Almorah fine-grained evenly-bedded quartzites and mica schist form the hill itself, and supply material not to be excelled for

* Mr. Lawder is here in error in calling *Salajit* bitumen or mineral resin. It is an alum or native sulphate of alumina which forms on the aluminous shales in the hills. At least such is the *Salajit* of Nepal, where it is well known and from which it is more largely exported than from Kumaon. Wonderful medicinal virtues are attributed to it, and in the plains it often sells for its weight in silver (see Notice of a native sulphate of alumina from the aluminous rocks of Nepal, by J. Stevenson, Esq., Supt., H. C. Saltpetre Factories; Journal, Asiatic Society, Bengal, Vol. II, p. 321. Also On the alum or Salajit, of Nepal, by A. Campbell, Assistant Surgeon, &c., &c., *ibid*, p. 482; also a second note by Mr. Stevenson, p. 605). Whether the mineral referred to by Mr. Lawder be really the same as *Salajit* I cannot assert.—T. OLDHAM.

durability and facility of dressing. Mica schist seems to form the principal beds for some distance to the east and west of Almorah, reaching to Dwara Hat and Massí on the west, Palí, Raníkhét, Síahí, Deví, Dole, and towards Kalí Kumaon to the east, and also in the formation of the Jagésur and Binsar ranges to the north.

At Nainí Tal the stones used are limestone and clay schist.

At Raníkhét a pale colored gneiss forms both a handsome and a lasting building stone.

Sandstone is abundantly found in the lower hills.

Gneiss and chlorite schist are used frequently as building stones in the district.

Imports.—The chief importations are BORAX (Tincal), SALT, and GOLD from Thibet.

BORAX.—Borax is obtained from the borders of a lake at Chappakanni, a few koss from the Kylass mountain in Thibet.

It is collected from June to September and sold at the several fairs—Ganpa, Gupa Chín, Sibbillum, Chakra, Taklakhal, Dhabakar, &c. It is purchased here by the Bhootea traders and brought down to Bagésur. At these fairs the price of crude borax is something under 2 Rupees per maund (about 50 seers), and in the same state it fetches from Rs. 8 to 9 per maund at the Bagésur Fair, which is the chief mart of the Jowarí traders. The borax bought up here is despatched to Ramnagar, where it is refined and redisposed of at about Rs. 22 to 24 the maund.

Traders from the Byanse, Chowdanse, and Darma Passes transact sales of borax at Dharchula and Burmdeo, and the Gurhwal Bhooteas from Niti at Kanaseo and Ramnagar, nearly all the borax is disposed of to plains traders—

Probable amount of borax brought through Milum Pass in 1868-69	...	17,000 mds.
Probable amount of borax brought through Darma and Byanse in 1868-69	...	15,000 „
Probable amount of borax brought through Niti and Mana in 1868-69	...	15,000 „
TOTAL	...	47,000 mds.

SALT.—Is found at Rhuduk in Thibet, and is sold at the same fairs as borax. It is also found at Silungsakka in Thibet—

Probable amount imported *viâ* the Jowar Pass (Milum) in 1868-69	...	4,000 mds.
Probable amount imported *viâ* Darma and Byanse in 1868-69	...	3,000 „
Probable amount imported *viâ* Niti and Mana in 1868-69 ...	...	2,000 „
TOTAL	...	9,000 mds.

Salt is purchased in Thibet at the rate of 1 Rupee 12 annas per maund (roughly measured) and sold at Bagésur or Almorah at from 5 to 6 Rupees per maund. Almost all the salt imported from Thibet is consumed in the hills.

GOLD.—Is found in many of the rivers in Thibet; at Silungsakka, &c.; it is sold at the same fairs as the salt and borax either in nuggets or in grains. About 10 to 12,000 Rupees' worth is brought down annually, some of which is disposed of in the hill districts (Kumaon and Gurhwal), probably about one-third, and the remainder most likely finds its way to Delhi, Agra, &c., &c. It is sometimes found to contain copper.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah KUMAON *for the year* 1868.

Name of Putti.	Name of Mines.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after melting ore.	Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of lead.	Mines of slates.	Mines of lime.	REMARKS.
					Maunds.	Maunds.	Maunds.	Maunds.					
Kutowli	Suyalgarh ...	Iron ...	By digging rock.	600 *	1	50	8	7	Salt, borax, gold imported from Bhoot, north of Kumaon. Copper chiefly imported from plains.	There is one mine of lead in Puttí Kharai, which is lying unworked.	There are many mines of slates in the district.	There are eight mines of lime, one in Kharai, one in Geewar, one in Kosyan, and one in Boraran, one in Shore, one in Síra, one in Dhyanírao and one in Charál.	Partly sold in the neighbourhood and partly brought to Almorah and Huldwaní.
Ramgarh	Dusonla ...	,,	,,	4,200	200	300	150	150					Bageesur, ditto ditto.
	Buna ...	,,	,,	2,000	90	140	70	70					Ditto, ditto ditto.
	Pálí, &c. ...	,,	,,	2,200	110	160	80	80					Ditto, ditto ditto.
Agar	Pathora ...	,,	,,	4,000	130	200	100	100					Ditto, ditto ditto.
	Mujera ...	,,	,,	4,400	100	300	100	150					Ditto, ditto ditto.
Geewar	Ketsarí ...	,,	,,	8,800	100	600	200	200					Ditto, Ramnagar ditto.
	Goodí, &c. ...	,,	,,	8,000	50	700	200	200					Ditto, ditto ditto.
Buraon Gungúlí ...	Raní	Copper.	Deep shaft.	3,840	1	10	8	9					Ditto, ditto ditto.
Burra Gungúlí ...	Belarh ...	,,	,,	200	1	1	1	1					Ditto, ditto ditto.
	Lettí, &c. ...	,,	,,	540	......	1	2	2					Ditto, ditto ditto.
Kharai	Goul	,,	,,	2,200	......	2	...	6					Ditto, Thul ditto.
Barabísi, Síra ...	Haralí ...	,,	,,	3,840	1	3	8	10					Ditto, Shore, Ramésur ditto.
	Puthrowlí ...	,,	,,	200	......	1	1	1					Ditto, ditto ditto.
Tullí Rao	Munglalékh ...	Iron ...	By digging rock.	4,200	200	300	150	150					Ditto, Burmdeo ditto.

* These numbers express the number of men for one day.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah GURHWAL *for the year* 1868.

Name of Puttí.	Name of Mines.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after melting ore.	Amount of metal exported and to what direction.	Mines of sulphur.	Mines of slates.	REMARKS.
Dhanpúr	Dhanpúr	Copper...	Deep shaft	1,200	Quantity not discoverable.	Not sold, but worked on spot.	Not melted yet.	None.	There are two mines of sulphur in Mulla Nagpúr and one in Mulla Dusowlí which are all lying unworked.	There are many mines of slates in the district.	Partly sold in the neighbourhood and partly brought to Sreenagar Bazar.
Ditto	Tachída	Lead ...	,,	100	3 mds.	3 mds.	...	...			Sold at Sreenagar.
Talla Chandpur ...	Sakund	Iron ...	,,	600	60 ,,	...	7 mds.	...			Is sold within the Puttí.
Talla Kaliphat	Rukhan	,,	,,	50	24 ,,	120 ,,	20 ,,	...			Ditto ditto.
Mulla Dusowlí	Dumtí	,,	,,	200	100 ,,	100 ,,	30 ,,	30			Purchased by the people of native Gurhwal, Barasyún, and Sulan.
Ditto	Kalabun and Mokh ...	,,	,,	500	400 ,,	400 ,,	100 ,,	100			Ditto ditto.
Sili Chandpúr	Rajbínga	,,	,,	1,100	...	120 ,,	15 ,,	...			Sold within the Puttí.
Boongí	Buwaní	,,	Collected from different marts.	120	20 ,,	20 ,,	...	...			Ditto ditto.
Lohba	Simulkhét	,,	Deep shaft	2,250	400 ,,	1,800 ,,	223 ,,	223			Sold at Ramnagar and in native Gurhwal.
B. Nagpúr	Jugtolí	,,	,,	250	150 ,,	...	10 ,,	...			Sold in the neighbourhood.
Ditto	Bukunda	,,	,,	150	80 ,,	...	6 ,,	...			
Ditto	Gooleth	,,	,,	80	60 ,,	...	4 ,,	...			
M. Nagpúr	Hat Jaisal	,,	,,	110	3 ,,	4 ,,	1 ,,	...			Sold within the Puttí.
Painu	Chulya	,,	By digging earth.	184	3 ,,	12 ,,	...	...			Ditto ditto.
Jériakote	Dandatolí	,,	,,	150	25 ,,	16 ,,	8 ,,	...			Ditto ditto.

GURHWAL;
SENIOR ASSTT. COMMR.'S OFFICE,
CAMP ALMORAH,
The 3rd April 1869

(Signed) C. J. GARSTIN.
Offg. Senior Asstt. Commissioner.

Captain Garstin, in submitting the numerical return from Gurhwal, says—

"The return has been prepared from statements sent in by Putwarees, and I do not think any great reliance can be placed on their correctness, as it must have been most difficult for them to find out the information required; the people working the mines themselves not having the slightest idea of the amount of ore they either collect or sell.

"The copper mines in Dhánpur used formerly to bring in a much larger revenue than they now do; the fact being that the shafts have been sunk so deep into the hill, and the passages are so intricate, that very few people will venture into them. The miners also say, that the mines are nearly worked out.

"There is, one may say, no export of ores from this district, the mines worked only being sufficient to supply the wants of the people.

"I regret that I cannot give further information, but the agency at my disposal is too limited to enable me to collate any that I would deem trustworthy."

1*st July* 1869. A. W. LAWDER.

The mines noticed in the above return have been known for many years. Some of them were noticed by the earliest European visitors to these hills. And when there was no communication with other countries and no supply of imported metal, they were naturally of higher importance and of greater value than in later years, when their rudely extracted products have had to contend with European manufactures. The earliest description, *in any detail*, of these sources of mineral wealth was given by Captain J. D. Herbert in 1829 in his report on the mineral productions of that part of the Himalaya mountains between the Sutlej and Káli (Gágra) rivers, &c. (Asiatic Researches, xviii, Pt. 1, 227). In this almost every locality noted above is mentioned. Dhánpur and Dhobrí at that time paid a revenue or royalty for the right of working of Rs. 1,200 per annum; Gangúli and Síra of Rs. 1,000; Pokri Rs. 600. The localities, modes of working, and rocks are described, and the means of improvement noted. The iron and lead mines are also noticed, as well as the non-metallic products of the hills—sulphur, alum, bitumen, graphite, borax, limestone, &c., &c. The inaccessibility of the various places is also noticed.

In 1838 a report on the copper mines of Kumaon by Captain H. Drummond appeared in the Journal of the Asiatic Society of Bengal (vol. vii, p. 934). In this he gives the results of an examination of many of the mines by a practical Cornish miner, Mr. Wilkin, whom he had brought out from England. The Rye (Rai) and the Sheera (Síra) mines, both noticed above, are specially referred to. Mr. Wilkin recommended certain trials and improvements in the mode of working, taking a favorable view of the prospects. An experimental trial was then made with the view of opening a regular mine at Pokri, in Gurhwal. Extensive workings had here been carried on from very early times, and one mine, called the Rajah Khán or Rajah's mine, had, it is said, yielded in one year more than Rs. 50,000. At the time alluded to (1838-39) the right of mining was leased for Rs. 100 per annum. Two galleries or adits were commenced, one in each of the two ravines in which the copper was known to occur, the Rajah Khán and the Chumitti ravines, about 500 yards apart. Up to May 1839, 149½ feet had been opened in the Rajah Khán drift, and 111 feet in the other. (Lieutenant Glasfurd, On the experimental copper mine in Kumaon, Jour. Asiat. Soc., Beng., viii., 471).

The work was continued until June 1841, when the estimated cost had been largely exceeded, and as no sufficient returns were obtained, the trial was finally stopped. At that time 257½ fathoms of ground had been driven through. In addition to the two old mines noticed above, the Rajah's and Chumitti (or Chaomuttee), a new opening was made, when good specimens of ore were found near the surface, but at a depth of 15 fathoms they ceased, and at 23½ fathoms it was abandoned. Details are given by Mr. Wilkin as to other mines in the neighbourhood of Pokri also.

The total sum expended in this experimental trial was Rs. 7,384 and there was realized by sale of copper during the time Rs. 779⅓. Mr. Lushington, who gives these details, mentions the real obstacles to success which have to be contended with. The distance of the mines from the plains, the slowness and expense of carriage, the cheapness and abundance of English copper, the superficiality of the mines yet known, and the want of coal are all serious drawbacks.

At the time Mr. Lushington wrote (1843) the mines of Dhánpur were rented for Rs. 1,700 per annum in 1812. Under the Ghoorka Government, the rent fixed for mines for the whole province was only Rs. 3,500 (Company's Rupees). Since 1815, when Kumaon was conquered by the British, up to 1846, the *average* revenue derived by the British Government was for copper in Kumaon Rs. 800 to 1,200, in Gurhwal Rs. 2,086, the highest revenue for any year, for all mines being Rs. 5,417. Iron yielded an average of Rs. 1,900 in Kumaon, and Rs. 226 in Gurhwal. (Account of experiment at Khotree copper mine, with notices of other copper mines, by G. S. Lushington, Esq., Commissioner, (Jour. Asiat. Soc., Beng., xii., 453).

Again, in September 1845, Mr. Sigismund Reckendorf, Mining Engineer, reported on the same mines, (Jour. Asiat. Soc., Beng., xiv, 471). Dhánpur and Pokri are on opposite sides of the Douliganga, each about six miles from the river, or 12 miles apart. Dhánpur is 1,000 to 1,500 feet higher than Pokri. Both are said to be on the same layer of talcose slate, which is stated to head north-15°-west. Mr. Reckendorf thinks, indeed, that the whole of the known copper mines from the Nepal terai on the east to beyond the Pokri mine on the west are only parts of one layer of no great thickness, sub-divided occasionally into two or three! He considers the ore not to occur in a regular lode or vein, but in a bed. He thought all previous trials had been misdirected, as they had been carried out in the old workings, and that new ground altogether ought to be opened up. He formed a much poorer idea of the chances of success at Dhobrí, but considered that everything tended to show that at Pokri copper could be obtained in large quantity. He urgently deprecates, however, Government attempting anything itself.

In 1854 the Hon'ble Court of Directors sent out Mr. W. Jory Henwood, with two mining assistants and an iron smelter, to examine and report on the metalliferous deposits of Kumaon and Gurhwal. After going over all the districts, Mr. Henwood reported in May, 1855. This report gives much useful information, but, so far as regards the copper mines, the opinion formed was most unfavorable, and indeed condemnatory. Speaking of Pokri he says: "We have never before seen a spot so scantily sprinkled with ore, and offering, in our judgment, so small a prospect of improvement so extensively and perseveringly worked." (Selections from Records of Government of India, Home Department, viii, p. 5). The greater part of the report is devoted to the rich iron deposits of these hills, regarding which we cannot at present speak.

Subsequently to this (1855) I know of no systematic attempt to work the copper mines of Kumaon or Gurhwal. The native miners have, however, continued to delve out annually in a wretchedly insecure way a few hundred maunds of ores, an amount which, from Mr. Lawder's returns given above, appears to be more considerable than I should have expected.

The Geological Survey has not yet had an opportunity of visiting these hills.

October, 1869. T. OLDHAM.

COAL-FIELD NEAR CHANDA, CENTRAL PROVINCES.

Since the first notice of this field was published in the Records of the Geological Survey (August 1868, p. 23), a systematic examination of the field has been commenced. It was fully pointed out by Mr. W. Blanford, in the paper referred to, that the country was in parts so covered that it would be impossible to obtain any satisfactory knowledge of its structure without boring or sinking. Since then two skilled borers and boring tools have been obtained from England, and further sets of tools are on their way. The season had already far advanced before these were available, and as the rains were then near at hand, it was considered desirable that these men who had just arrived, and who were therefore quite unacquainted with the peculiarities of life in this country and of the climate in which they were to work, should, for a time at least, be kept where good house shelter could be obtained. The work was placed under the immediate charge of Mr. M. Fryar, M. E., Mining Assistant on the Geological Survey. And he was requested to select spots for boring within reach of Chanda or Ballarpur during the rainy season and to keep the men at first together, so that they could aid one another in any difficulty which might occur at first starting.

Under Mr. Fryar's instructions the first bore-hole was commenced in the beginning of June. This bore-hole (No. 1) was very near the south-east corner of the boundary of the Nuggeena Bagh, north of the native town of Chanda. This bore was put down 80 feet

and was then stopped, "as the material bored through continued to be simply stiff sand." A second bore was then commenced about 230 feet from the first, in the direction of the dip of the rocks,—about east-15°-north. This passed through the following section:—

	Feet.	Inches.	
	12	0	Of ochrey arenaceous shale.
	8	0	Soft shale of deep red and purple colour.
	20	0	Of the same material as found in No. 1 bore-hole.
Total ...	40	0	

At this depth, 40 feet, this bore-hole was also stopped.

No. 3 was then commenced at about 450 yards still further in the direction of the dip, or into the field, or about 527 yards from No. 1. This bore-hole was near the junction of the Ghimoor road and the Nagpur road, its bearing from No. 1 (magnetic) being about north-38°-east.

This third boring gave the following section:—

	Feet.	Inches.	
	5	0	Brown soil.
	11	0	Red brongel.
	3	0	Brown sand.
	1	0	Hard red ironstone.
	17	0	Light pipe clay.
	2	0	Dark brown clay.
	12	0	Soft light sandstone.
	3	0	Light brown sandstone.
	10	0	Light colored sandstone.
	7	0	Very light colored sandstone, very coarse.
	2	0	Yellow sandstone.
	4	0	Very dark sandy shale.
	25	0	Variegated sandstone.
	10	0	Yellow sandstone.
	11	0	Brown sandstone.
	9	0	Variegated sandstone.
	1	0	Coarse brown sand.
	25	0	Variegated sandstone.
	2	0	Light blue sandy shale.
	2	0	Good *coal (a).*
	12	0	Very dark blue shale, a little sandy.
	7	0	Light blue sandstone, a little shaly.
	24	0	Light colored sandstone.
	1	6	Black shale mixed with *coal (b).*
	16	0	Light blue sandstone.
	1	0	Dark sandy shale.
	0	6	Iron pyrites.
	18	0	Light blue sandstone and brown sand mixed.
Total ...	242	0	

"And as in this depth we have entered something of a Talchir appearance, I have stopped this hole and commenced one at Ballarpur." (Mr. Fryar's report, 24th July).

Specimens of the *coals* passed through in this pit, as brought up by the pump, were assayed, and yielded—

	Carbon.	Volatile.	Ash.
(a) two feet bed	47·8	41·0	11·2
(b) eighteen inch bed...	42·7	41·2	16·1

both poor coals, neither containing 50 per cent. of carbon. The beds are also from their small thickness unworkable with profit at that depth.

A fourth boring was made near the dâk bungalow to the west by south, and between the bungalow and the Jhurput nala. This (No. 4) was put down with small rods, "and ought to have entered coal a few feet from the surface, if the apparent dip of rocks at the surface had been a guide approximately to the dip of the coal beds below." (Mr. Fryar, 28th July). This boring was about 500 feet to the west of one put down by Mr. Binnie, C. E., in which coal was said to have been cut. No. 4 did not reach coal, and was abandoned.

Preparations were made for a fifth boring (No. 5) about six chains from the Jhurput nala on the left bank, due south of the town of Chanda, but no boring was carried out here.

At Ballarpur, the first boring alluded to above was put down on the left bank of the river, nearly opposite the point where coal is seen on the right or Hydrabad side of the river, and about 300 feet from the river bank. This position was injudiciously selected, as proved to be the case. It was in fact within the limits of the old bed of the river, and was

abandoned, as there was not tubing "enough to carry the hole through the running sand and gravel met with." This difficulty might certainly have been avoided, but unfortunately it was not. The probability was in fact pointed out in April 1867 (see p. 25, Records, Geological Survey of India, 1868), where it is said, "in sinking upon the Chanda side, it is far from improbable that only alluvial clay may be met to the depth mentioned." The boring tools were then shifted to a second position where rocks were visible close by. This second hole was put down about a mile to the north-east near the town of Ballarpur (less than half a mile). This boring was carried down to a total depth of 236 feet.

The following is the section passed through :—

	Feet.	Inches.	
	3	0	Red iron brongel (moorum).
	6	0	Soft brown sandstone.
	9	0	Strong blue clay.
	2	0	Very dark-red sandstone mixed with iron.
	10	0	Brown sandstone.
	30	0	Soft light colored sandstone.
	12	0	Variegated sandstone.
	1	0	Red sandy clay.
	6	0	Dark colored sandstone.
	3	0	Brown sandstone.
	1	0	Hard red sandstone mixed with iron.
	10	0	Brown sandstone, with mica.
	16	0	Yellow sandstone.
	0	9	Good *coal.*
	0	9	Black shale.
	1	6	Good *coal.*
	2	0	Very dark shale.
	3	0	Green looking sandstone (blueish).
	10	0	Dark-blue sandstone mixed with shale.
	26	0	Light colored sandstone.
	0	9	Iron pyrites.
	26	0	Light colored sandstone.
	2	10	Black shale, a little coaly.
	10	0	Dark blue sandstone mixed with shale.
	26	0	Light colored sandstone.
	0	9	Iron pyrites.
	0	9	Light colored sandstone.
	3	0	Black shale, a little coaly.
	11	6	Dark colored sandstone, a little shaly.
	1	6	Iron pyrites.
	1	6	Light colored sandstone.
Total ...	236	7	

Mr. Fryar reported on the 16th September that he had ordered this hole to be stopped, "as we are evidently in the Talchir sandstones." He adds, 'you will observe a similarity of section by comparing the second hole at Ballarpur with the No. 3 one at Chanda' (given above). There is doubtless some little similarity, but I am unable to see the proof that the bore was evidently in the Talchir beds.

The boring rods were then moved from Ballarpur to a point on the road to Moolk from Chanda, between two and three miles from Chanda town, near the place where the road crosses the Jhurput nala, in the corner between the stream and the road to the south of the road. This boring was in progress up to date of last report, and on the 12th instant had reached a total depth of 124 feet 6 inches. The following is the section :—

	Feet.	Inches.	
	5	0	Loose sand and loamy soil.
	6	3	Yellow sandstone and bands of ironstone.
	1	3	Hard red ironstone.
	7	0	Variegated sandstone, with little clay.
	11	0	Soft red ironstone.
	0	6	Ironstone band.
	8	0	Red sandstone mixed with iron.
	4	0	Yellow sandstone.
	11	0	Variegated sandstone.
	1	10	Yellow sandstone.
	0	8	Very hard red rock.
	7	6	Brown sandstone.
	28	0	Light brown sandstone.
	9	0	Light red sandstone.
	1	0	Coarse light brown sandstone.
	2	6	Hard red rocks.
	20	0	Variegated sandstone.
Total ...	124	6	

It is evident that the rods have not yet touched a bed of the coal-bearing rocks in this section, all the beds passed through belonging to the Upper or Panchet series.

Reviewing the results thus obtained, we find that borings at Chanda, which are represented as having passed through the entire thickness of the coal-bearing rocks there, and to have pierced the Talchir beds below, (in which no coal is known), exposed only two thin beds of poor coal, so thin as to be unworkable. While at Ballarpur also, a boring of about the same depth (about 240 feet), said in like manner to have gone through the entire thickness of the coal-bearing rocks and to have pierced the Talchirs, showed also two beds of coal, one of 18 inches, one of 9 inches in thickness.

It need scarcely be said that none of these are workable at the depth at which they occur.

Before these explorations had commenced, Major Lucie Smith, Deputy Commissioner of Chanda, who deserves the highest credit for the sustained zeal and intelligent earnestness with which he has prosecuted these enquiries, had a pit opened on the bed of coal visible in the Wurda channel, near Googoos, or Chendoor. And from the coal there met with, at a depth of 30 feet below the surface, a considerable quantity was raised for experimental trials to which I will presently refer. As, however, this pit was within the limits of the ordinary flood level of the Wurda, a bore-hole was put down about 330 yards from the bank of the river and nearly in the line of strike of the beds. This bore-hole was carried out by Corporal Carson, of the Public Works Department, under the orders of Major Lucie Smith, Mr. Fryar also assisting. As was tolerably certain at such a distance the coal was found to continue. This bore-hole was sunk altogether to 121 feet 6 inches, and gave the following section :—

	Feet.	Inches.	
	3	0	Surface clay.
	5	0	Red moorum.
	40	0	Variegated sandstone.
	8	0	White sandstone.
	6	0	Yellow clay.
	10	0	Dark-brown clay.
	2	0	Black shale.
	3	0	*Coal.*
	3	0	Dark sandy shale.
	3	0	*Coal.*
	5	6	Blue shale.
	12	0	*Coal.*
	4	0	„ mixed with iron pyrites.
	5	0	*Coal.*
	0	6	Shale.
	11	6	*Coal.*
Total ...	121	6	

Below this is white sandstone streaked with black shale. It is much to be regretted that the boring was not continued, so as to ascertain the thickness of the formation here and the position of this thick deposit of coal in it.

The coal having thus been proved here, a pit was commenced and is now in progress.

A second bore-hole was then commenced about a mile to the south, and to the west a little south of the village of Googoos. This is as nearly as can be the locality recommended by the Geological Survey in 1867, "about 300 yards west of the village of Googoos." This bore-hole was carried down in all about 112 feet, giving the following section :—

	Feet.	Inches.	
	6	0	Surface clay.
	22	0	Variegated sandstone.
	0	3	Ironstone.
	21	6	Variegated sandstone.
	2	6	Red rock.
	4	0	Yellow clay.
	6	0	Dark shaly clay.
	3	6	Shale.
	2	0	Crimson colored sandstone.
	17	0	Clay and sand.
	20	0	Light colored sandstone.
	7	0	Variegated sandstone.
Total	111	9	

At this depth the mineral lifter jammed, and after several days' unavailing efforts to lift it, it became evident that it would be necessary to sink to it, in order to relieve the tools. After some delay this sinking is now in progress and had reached 27 feet on the 12th instant.

Such is the progress made in the exploration of the field.

As regards the important question of the quality of the coal, several trials have been made. The coal raised from the pit near Googoos was first sent to the Great Indian Peninsular Railway for trial in their locomotives. The Locomotive Superintendent reported on the 16th April "that the coal was not suitable for locomotive purposes, being very dirty. Out of 1 ton 4 cwt. used, there were 6 cwt. of clinker, but very little in the smoke-box, with a load of 4 cotton wagons and one brake. Great quantities of sparks came out from the chimney, and remained on fire for some time. From Boorhanpore to Khundwa, the brake-van alone was attached to the engine, and although the fire had been cleaned at Chandnee station, it had to be cleaned again before getting to Dongergaon (17 miles). We could not get a welding heat with the coal, although it contains great quantities of gas."

The fire-boxes on the Great Indian Peninsular Railway are constructed to suit English coal, and the engineers are accustomed to its use. There appeared, therefore, sound reason for not admitting this to be a conclusive trial. More coal was raised, and better coal selected, and this was sent to the East Indian Railway at Jubbulpore, some to the works in progress under the Public Works Department at the Kanhan bridge, and also a second supply to the Great Indian Peninsular Railway. The results of these trials are decidedly encouraging. It is said that the coal took the train on the Great Indian Peninsular Railway down as far as Budnaira (100 miles) without difficulty; the engineers were agreeably surprised with its capabilities, but did not "think it quite up to the mark." At the Kanhan bridge works, it was tested in a small portable engine. "With Chanda coal steam was got up in 1 hour and 25 minutes with a consumption of 36lbs., the coal being wet, a strong breeze blowing and rain falling at the time. The coal burnt clear, and freely and very clean, leaving a small residue of gray ash without clinkers, and evaporated on the average 4lbs. of water per 1lb. of coal consumed. With English coal steam was raised in 1 hour 35 minutes, with a consumption of 28lbs., the coal being drier, but small and deteriorated from exposure, but the weather was fine at this part of the day and very little wind. The evaporation was at the rate of 6·5lbs. of water per 1lb. of coal." The Chanda coal is specially noted as "burning clean."

The trial on the East Indian Railway was the only one in which the Chanda coal was compared with other Indian coal. "The Locomotive Superintendent reports that the consumption of Chanda coal on two trials was 88¾ cwts. and 85 cwts. per 100 miles, against 67 cwts. of Ranigunj coal for the same distance. The coal did not work well at first, partly, it appears, owing to the construction of the fire-boxes, and partly, perhaps, to the stormy weather in which one of the trials was made, but it did better afterwards."

These trials show the 'duty' of the coal to be as compared with English coal ('small and deteriorated by exposure') as 4 : 6·5, or 61 per cent., or, in other words, it is ⅗ths worse than this English coal.

As compared with Ranigunj coal, its duty was as 67 to 87 (mean of 88·75 and 85·), or 77 per cent., or nearly ¼th worse. It is not stated what "Ranigunj" coal was in use.

The coal, however, did the work required of it, and in a satisfactory manner.

These coals were, as mentioned, from the pit sunk at the Wurdah. To test the coal met in the boring near that river, as given above, Mr. Fryar was requested to forward specimens. Of these he sent 33, one from each of the three-feet seams above the thick coal and 31 from it, these being taken from the material brought up by the pump at intervals of about a foot of sinking. These were all assayed carefully by Mr. Tween, and the results are given below.

There can be no doubt that assays of this kind, and more especially when made on the stuff broken down by a boring-chisel, are only approximate indices to the value of the coals tested. But in the absence of better means, they do afford fairly comparable results, and do unquestionably give a fair indication of the economical value of the coals. Indeed, the very results given above are singularly confirmatory of this. The assays were completed for several weeks before the above results of actual trials were received.

The 33 specimens tested gave the following results:—

Depths, &c.	Carbon.	Volatile.	Ash.	Depths, &c.	Carbon.	Volatile.	Ash.
A (1st three-feet seam) ...	46·9	44·0	9·1	16	38·5	36·7	24·8
B (2nd three-feet seam) ...	37·4	28·0	34·6	17	44·2	31·4	24·4
1 (from thick coal)	48·0	36·6	15·4	18	29·3	23·5	47·2
2	45·5	36·4	18·1	19	36·8	33·0	30·2
3	44·0	39·4	16·6	20	43·0	39·6	17·4
4	43·5	40·0	16·5	21	46·3	41·1	12·6
5	44·4	39·8	15·8	21*	44·9	42·5	12·6
6	44·7	39·5	15·8	22	42·7	30·6	26·7
7	47·4	36·8	15·8	23	45·3	33·0	21·7
8	47·7	36·8	15·5	24	52·4	32·0	15·6
9	47·6	40·0	12·4	25	40·3	24·5	35·2
10	48·2	39·8	12·0	26	45·6	32·8	21·6
11	46·6	44·6	8·8	27	44·2	29·0	26·8
12	40·7	44·5	14·8	28	55·1	32·0	12·9
13	60·4	33·[illegible]	6·6	29	35·6	32·8	31·6
14	38·3	28·1	33·6	30	56·2	31·6	12·2
15	37·8	28·8	33·4				

It is obvious from these results that while this thick deposit contains some layers which are really good coal, there is also a large amount which is scarcely deserving of the name of coal at all. Stuff with 30 and 40 and even up to 47 per cent. of ash—useless matter—would be of no avail excepting for purely local demand in such work as lime-burning, &c., while coal such as is represented by No. 13 or No. 30, or the bed A, would hold just comparison with some of the best coals in India. Probably the fairest way, seeing that although the specimens are taken from about every foot, the actual matter assayed may really represent only an inch or two in thickness, is to take the whole as one, and take as the mean composition the average of all the results (neglecting for the present the two separate 3 feet seams). And for comparison, to take 30 specimens of Ranigunj coals from different worked beds, and take the average composition of these.

Taking the 31 specimens of the Googoos coal, the average result of all is—

Carbon	44·51
Volatile	35·34
Ash	20·15

And the average result of 30 Ranigunj coals is—

Carbon	50·9
Volatile	34·6
Ash	14·5

that is, the Googoos (average) coal is 6·39 per cent. inferior to the *average* of Ranigunj coals as to the main heating power, and it is also 6 per cent. worse than the same as to amount of useless matter. Or, viewing it in another way, it may be said that out of the 31 odd feet of 'coal' there are 28, which contain less carbon than the *average* of 30 Ranigunj coals, good and bad, and only 3 which contain more; while there are 23 which contain more ash than the same average, and only 8 which contain less.

These results appear unquestionable, so far as the coal yet obtained is concerned. That this coal will at the same time prove highly useful cannot for a moment be questioned; and we must only continue to seek for better.

The results of these trials showed the duty of Chanda coal roughly, as compared with Ranigunj coal, to be as 67 to 87. The comparison by assay gives 45 : 51, or the trial by rail gives the work in the ratio of 1·00 : 1·29, that by assay as 1·00 : 1·14. As compared with English coal the duty was by actual trial as 4·0 to 6·5, by assay as 44·5 : 68, or, in the first case, as 1 : 1·63, in the latter as 1 : 1·53.

These are very close approximations and fully bear out the value of such assays. In all cases, it is worth notice also, the result as per assay is more favorable than that by actual trial. Both methods of testing the value prove that good useful fuel exists near Googoos in considerable quantity.

The explorations are being carried on with vigour, and the results will be given from time to time.

In connection with this enquiry, it is necessary to give publicity here to some important facts regarding which considerable misapprehension has evidently existed. In the last general report on the Central Provinces, the Chief Commissioner has (p. 76) said: 'so far coal has only been discovered in that known as the Damuda series, and it remains to be proved whether the Kamptee group is carboniferous.' This name 'Kamptee group' has never been published before or defined, and without such definition it is meaningless. It was a term used by Mr. W. Blanford on a preliminary sketch map of the district, copy of which was given to the officer of the Geological Survey working at Chanda for his information. But the term was simply one of convenience, and for temporary local use as applied to a series of beds in the vicinity, and signifying nothing more than those local beds; simply a name used instead of a long phrase to convey certain peculiarities in texture, &c. It is one of many such short names which, used for a time merely locally, give place to others when relations and connections have been traced out. It has therefore never been published or used in any other way than as a term of convenience among the officers of the Geological Department. It is in fact meaningless without definition.

But having thus been used, I may state that the local beds so called "Kamptee" are nothing more nor less than the Central Indian representatives of the great *Panchet* series of rocks, so well seen in the Ranigunj coal-field, still better developed in the Jherria, the Bokaro, the Karunpura, and other detached coal-fields towards the west, and which series of rocks can be (and have been) traced across all the intervening country up to Nagpur and Chanda. And as in the Ranigunj field, so in every other section exposed throughout the hundreds of miles of country (thousands of square miles) not a trace of coal is known to occur in them. This induction is far wider and far more satisfactory than any examination of the Central Provinces alone could afford.

But, in addition to this, accompanying this extension and development of the Panchet series, there is, from east to west, a steady and continuous but rather rapid diminution of the true coal-bearing rocks (the *Damuda* series), so that the formation which in the east is of several thousand feet in thickness, with more than one hundred beds of coal of varying thickness, and which is there easily divisible into three groups, on passing to the west so dwindles down, that, in the Nerbudda valley and in the Chanda field, the total thickness of the formation does not exceed as many hundred feet as it was thousands in the east, and that all the coal is confined to a few beds of great irregularity near the base of the series. These facts also have been established not by any local investigation, but by a long continued and systematically carried out series of examinations and measurements spread over hundreds of miles of the country.

There appears not a doubt as to the fact that coal does not occur in the Panchet rocks. There is equally no doubt that coal is not in the Talchir rocks below, and the simple point that remains to be proved in the Chanda field is the extent, thickness, and value of the coal which does accompany the Damuda rocks. If the country were not so much covered the limits of these rocks could readily be traced; there is no difficulty in distinguishing them. But unfortunately there is a large part so concealed by superficial deposits that the existence of these coal-bearing rocks must be probed out by boring. And this is what is now being done by the Geological Survey for the Government of India.

The borings at Chanda and at Ballarpur given above are additional proofs of the very limited thickness of these rocks. The entire thickness of the Damuda series, as it there exists, together with all the overlying beds, is said to have been passed through within about 235 feet. Of this more than one-third belongs to the upper series, leaving the thickness of the entire Damuda or coal-bearing formation here not more than about 150 feet!

The 18th October 1869. T. OLDHAM.

LEAD *in the* RAIPUR *District:* CENTRAL PROVINCES.—To the information already given regarding this lode of lead-ore but little has been added since then (*see* Records, Geological Survey of India, 1862, Pt. 2, p. 37). At the close of the season, Mr. Smart, the Revenue Surveyor engaged in that district, completed a small plan of the locality and immediate vicinity on a scale of four inches to the mile. He found fragments of the metallic vein scattered upon the top of the hill, on which it was seen for a distance of half a mile from the spot where it was discovered last year. 'The direction of dip of the vein could not be ascertained owing to the confused and fractured arrangement of the surface rocks.' Mr. Smart had no means of proving the vein.

I hope to be able to have the locality examined this season.—T. O.

METEORITES.—To the kindness of Dr. Waldie we are indebted for the remaining portion of the specimen of the Khetree stone, (fell February 1867), which he analysed with care, and of which he gave an excellent description at the meeting of the Asiatic Society in June 1869. Dr. Waldie states how it is frequently so difficult to procure specimens of these highly interesting bodies which fall from the heavens, as the people, in their ignorance looking upon such visitors as evidence of the wrath of their deities, carefully reduce to powder and dissipate all the pieces which they can procure. Only two pieces are known to exist, both small; one is in the collection of the Asiatic Society, and this one in the collection of the Geological Survey.

From Dr. Tschermak, the successor of the much regretted Dr. Moritz Hörnes, in charge of the Imperial Mineral Cabinet at Vienna, we have also received a very good specimen of the fall which occurred at Slavetić, in Croatia, on the 22nd May, 1868, and described by the indefatigable Haidinger, on the 3rd December, 1868, to the Academy of Sciences, Vienna.

Also, a specimen of the Ornans (Doub) fall, of which we were already in possession of a fine piece through the good offices of M. Marcou, (see Records, Geological Survey of India, February, 1869). This fall took place on 11th July, 1868.

Also, a specimen of the very interesting stone which fell at Krähenberg near Zweibrücken (Pfalz) on the 5th May, 1869.

These valuable additions to our numerous collection are further proofs of the friendly aid and co-operation we have invariably experienced from the Geologists of Austria.

October, 1869. T. OLDHAM.

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OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. III.

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THOMAS OLDHAM, LL.D., F.R.S.,

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 1.] 1870 [February.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1869.

The close of another year (1869) calls for a brief summary of the progress of the Geological Survey since our last report.

The area, which it is possible to examine geologically within a year, depending essentially on the number and ability of the officers employed, it is necessary, first, to premise that during ten months of the twelve just passed, Mr. W. T. Blanford, Deputy Superintendent, was absent, being engaged in the elaboration of his report on the Geology and Natural History of Abyssinia, the result of observations made while attached as Naturalist to the Abyssinian Field Force, and during a brief visit, subsequently to the return of this force from Abyssinia, to the adjoining territory of Bogos. Mr. Blanford was, at the beginning of the year (1869), ordered to proceed to Europe, where alone he could have facilities for the comparison and identification of his collections and of reference to all previously published accounts. After an absence from India, on this duty, of about six months, Mr. Blanford rejoined the Geological Survey at the beginning of November, and immediately took the field. Mr. Ormsby, who (as reported last year) had been obliged to proceed to Europe, suffering from sunstroke, returned just before the working season commenced in November. During the most important and largest portion of the year, therefore, the survey was without the aid of these two gentlemen. Mr. W. King and Mr. F. Mallet obtained 12 months' furlough each, and left in September for Europe, having completed their maps and reports of the previous season; and their services will, of course, be wanting during the present season. Last year I had to report that Mr. Charles Oldham had proceeded on furlough in November, and with deep regret I was called on to report his decease in April last. In him the Government of India lost a trained and able servant, distinguished for his conscientious devotion to duty, and for the care and skill with which he, as Deputy Superintendent for Madras, conducted the labours of the party working there. In him also the officers of the Survey regret the loss of an esteemed colleague. This death, resulting from the effects of an attack contracted during his active service in India, adds another to the long list of those who have succumbed to the very trying exposure in the worst and most unhealthy parts of the country which the pursuit of Geology in India necessarily entails. The remaining officers of the Survey have all been actively engaged during the year.

Soon after the commencement of the year (1869), having then just returned from the Punjab, I proceeded to Cachar and Sylhet, to examine, on the spot, the evidence connected with the serious earthquake of the 10th of January, which had caused such extensive damage. I was unfortunate in visiting the localities just at the time when all the available carriage of the district was needed for the Military expedition then just leaving Silchar; so that I found it impracticable to see quite as much of the country as I could have wished. I succeeded, however, in obtaining some accurate and valuable observations. And in returning I crossed the Khasi Hills, noting the results of the same earthquake at Sylhet, Cherra Poonjee, Shillong, and Gowhatty. A brief notice of these results was given at a meeting of the Asiatic Society of Bengal in March (*vide* Proceedings of the Society for April 1869, p. 113). While working out these observations, I was led to notice how little of any accurate record existed in this country regarding the earthquake shocks to which many parts of it are

frequently subject. And I have, therefore, given some time to the preparation of as perfect a catalogue of Indian earthquakes as I had means of obtaining. This will, I believe, prove an useful addition to Indian seismo-statistics, and I trust may at the same time be the means of eliciting further information on the subject. Many private records of such phenomena doubtless exist, full of interesting and often valuable information, which has never been given to the public. I would solicit the contribution of any such facts as may tend to prove the occurrence of shocks not hitherto noticed, or to indicate the extent of area over which, and the relative violence or intensity with which, shocks already recorded may have been felt in different parts of the country. The very nature of such a catalogue precludes the possibility of successful compilation by any unaided individual; the co-operation of many is essential. A report of the effects of the earthquake of 10th January, 1869, is in progress.

At the beginning of November, I proceeded to the Central Provinces to control the operations there in progress for the exploration of the coal in Chanda and Berar. I found that the late rains of the year had caused a good deal of fever in many places, and the taking of the field by the Survey Party was a little delayed in consequence. Proceeding from Nagpore in company with Mr. C. Bernard, Commissioner of Nagpore, in whose jurisdiction the Chanda district is, I first took a general review of the field as far south as Ballarpur. And then returning fixed upon positions for future borings, with a view to test not only the continuity of the beds of coal which the river Wurdah had exposed in one or two places, but also to prove the nature, thickness, and contents of the coal-bearing formation generally. I have seldom seen a country less favorable for detailed Geological research, as a thick covering of clays conceals the rocks entirely, excepting at distant intervals. Any detailed examination, therefore, necessarily takes much time, and cannot in the end be very satisfactory. But, with the aid of borings, we hope to be able to trace out the rocks with tolerable accuracy.

The results of the trials up to November last were published in the last part of the Records of the Survey (Part 4, 1869), and it is not necessary to repeat them here. Since that time, up to date, additional information has been gained, which is all satisfactory. One of the great sources of doubt as to the extent of the coal deposits arose from the widely established fact, that the beds in the group of rocks in which the coal here occurs (that known to Indian Geologists as the Barakar group) had invariably a tendency to exhibit very great variation both in thickness and quality within short distances. They are often of great thickness locally, but thin out and nearly disappear within short distances: this variation also being not only in the thickness, but also in the quality of the beds, so that what shows as a bed of good coal in one place may, within a few yards or a few hundreds of yards, pass into a shale without coal, or even into a sandstone. It was, therefore, important to test this, and the first new boring which was fixed on was put down near the village of Telwasa, some ten miles to the north of where the coal had been found in the river. No coal was visible, nor had any been ever known to be there; but the position in which it ought to be found, if the beds continued, was, as appeared to me, well marked. After some delays, the rods were put down here, and passing through the beds of sandstone, seen on the surface, they entered a group of beds of coal and shale, in the proper position exactly as anticipated. Up to the close of the year, 19 feet of this coal, with a few shale partings, had been cut into and the beds still continued.* Near the village of Nokora also, to the extreme south end of the small area of coal-bearing rocks which occurs on the Chanda side of the Wurdah river, near Ghúgús, the limits of which had been approximately fixed by Mr. Blanford in 1866, a bore-hole was put down by Mr. Fryar to test the character of the beds there. This has cut the same group of beds with coal found to the north of Ghúgús village. There are representatives of the two upper beds, and then of the thicker group of shale and coal below. But, as expected, there is a large amount of variation in the actual section. The thick beds of so-called coal and shale noticed in the borings at the north of Ghúgús (see Records, Geological Survey, 1869, p. 97), as being there altogether some 33 feet in thickness, have increased to more than 50 feet at Nokora; but this increase in aggregate thickness is chiefly in the greater development of the earthy or shale beds. The details of measurements need not be given here.

The results, so far as the explorations have been carried, seem to me to point to the *general* continuity of the coals on a fixed horizon in the lower sandstones, and if this be confirmed by further examination, these coals may be sought for with considerable certainty within

* Forty-one feet, seven inches, of coal have been cut altogether here, in a total depth of 138 feet.

the very limited area which these rocks occupy. Until the recent trials, I regret to say that no principle seems to have guided the selections of the several points at which bore-holes were put down. They were apparently put down completely at hap-hazard, and were of course, in most cases, without any definite result. Localities have now been absolutely fixed upon for a number of additional borings, where, at comparatively small depths, the presence or absence of the coal may be determined.

A steam-boring machine has also been delivered at Chanda, but it is not yet in operation. It will in reality be of very trifling use in this field. The country is to an immense extent either covered with jungle or with deep beds of clay, through which every little stream cuts a deep channel or gully, and in either case there are no roads excepting of the most primitive character. There are not, therefore, more than half a dozen spots in the district to which this steam-boring machine can be conveyed, excepting at great loss of time and expense. And even in those localities, the required information can be obtained with ordinary boring tools more cheaply and expeditiously if only a systematic system of choice of position be acted upon. It is, however, hoped that a trial will soon be made with this steam-boring machine when the services of some one competent to undertake the management of it can be obtained.

To Major C. B. Lucie-Smith, Deputy Commissioner of Chanda, I am indebted for the most hearty and effective assistance in all things. The Geological Survey is also indebted to Mr. S. H. Hennessy, Extra Assistant Commissioner, for the earnest and friendly way in which he has ever met their wishes.

It is hoped that as soon as the Chanda district is examined, the investigations of the Geological Survey may be continued down the valley of the Godavery, at detached points in which we know of the existence of small basins of the coal measure rocks, in which coal may exist in good workable quantity. Such a basin, for example, occurs about 15 miles north of Dumagudiam, from which, at the place indicated by Mr. W. Blanford in 1866 near the junction of the Tal river. in the left bank close to the village of Lingala, a considerable quantity of coal was raised last year from the bed of the river. This coal worked effectively in the low pressure stationary engines, but was not sufficient to keep up steam for the high pressure engines of some of the steamers. I am also indebted to Colonel Haig, R. E., for the information that coal has been again found exposed in the scarped face of the rocks on the right bank of the river, about 34 miles below Dumagudiam. 'About two feet are seen above water level, and it extends under the water as far as a man can reach with his arm.' All these facts point to the necessity of an early and careful examination of this country. And it is my purpose next working season to work up from the Madras side, the party of the survey there engaged bringing up with them the extended knowledge they have obtained of the older groups of rocks in the Madras Presidency and the officers of the survey from Bengal working downwards, and bringing with them their widely acquired intimacy with the structure, character, and sub-divisions of the coal measures of India. The extent of country to be visited is, however, wide, and the detailed examination of so large an area will unavoidably occupy much time. The result of a systematic examination of this kind will, however, be more satisfactory and more trustworthy than if taken up at detached points.

In connection with these practical explorations by boring for coal, &c., I would notice the great satisfaction with which the Geological Survey have seen lately the success of that most important trial for water at Umballa. The insufficiency of the supply of water at this large station has long been a source of anxiety, and a cause of ill-health, and has led to proposals for the adoption of very costly and tedious works to increase the amount of available water and to facilitate its distribution. Mr. H. B. Medlicott, after his examination of the Sub-Himalayan rocks, urged the importance of seeking this much-needed supply of water in the water-bearing beds which must exist under all the country in that parallel along the foot of the hills.* The reasons for the confident expectation of good water being found there with a pressure at least sufficient to bring it to, or near to, the surface from very considerable depths were stated, and have, on several occasions since then, been very strongly urged. It was therefore with no small satisfaction that we saw the very first trial confirm the justice of these sanguine expectations. It is to be hoped that further trials will be now boldly

* Memoirs of Geological Survey of India, vol. III., pt. II, p. 181.

carried out, but at the same time strictly limited to those areas where the probable existence of similar conditions may be fairly anticipated after proper examination.

As stated in my last annual report Mr. Medlicott was, at the commencement of the year, engaged in the examination of the very important geological questions of the extent and stratigraphical relations of the several series of sandstones, &c., associated with the coal in Bengal as compared with those in Central India. In pursuance of this object, he traversed the entire country between Hazaribagh and Palamow on the east and Jubbulpur, on the west; and thence went southwards to Nagpore and Chanda. This extended and general survey of the vast area occupied by these rocks has brought into greater prominence and clearness, and has established the wider application of several of the views already enunciated by other officers of the Survey regarding the distribution and variation in character of the several sub-divisions of that great series of beds, in some members of which the coals of India chiefly occur, and which may, as a whole, and in a broad view of its fossil contents, be called the plant-bearing series. The vast extension and wonderful constancy in mineral character (combined with local peculiarities) of the *Talchir* rocks, which have always been treated of as the base of this great series, although forming in themselves a well marked and characteristic group, has been even more fully established than it previously had been. The dying out also in passing to the west of the distinctions so easily established in the eastern coal-fields, (Ranigunj, Jherria, &c.), where a three-fold sub-division of the true *Damuda* or coal-bearing rocks is obvious—a fact already fully indicated by Mr. Hughes, as far as the Bengal fields are concerned—has been shown by Mr. Medlicott to be entirely supported by the character of the rocks in the more western fields. And, at the same time, the co-existent fact of the considerable increase in the development of the group which occurs at the top of the series (the *Panchet* group), seems equally established. The entire group of the formations or series which in the east gives five well-marked sub-divisions *(Talchir, Barakar, Ironstone shales, Ranigunj,* and *Panchet)* becomes at only a short distance to the west only a three-fold series of the *Talchir*, the *Barakar*, and the *Panchet*. This was shown to be the case in some of the Bengal fields, and the same fact is more fully insisted on by Mr. Medlicott with reference to the country lying further west.

Although, so far as known, there seem good grounds for admitting this as giving the truest representation of the facts, it must at the same time be stated that the lithological character of each of these groups differ in the west and south from that of the typical rocks in the Ranigunj field and Talchir field. Even so near to Ranigunj as the Palamow (or Daltongunj field,) Mr. Hughes has shown that the *Barakar* rocks present a lithological character intermediate as it were between the true *Barakar* and the *Ranigunj* beds. And further, in the Bokaro field, he has pointed out the transitional passage of the *Ranigunj* beds into the *Panchets.*

With these facts, it would almost remain an open question, whether much of those upper beds, to which we are now disposed to assign the general name *Panchet*, may not represent, *in time*, the upper groups of the more eastern fields (*Ranigunj* beds, *Ironstone shale*). And the fossils contained would go to support this view. But the general mineral character very decidedly approximates more to that of the typical *Panchet* rocks, and throughout the entire area extending over many thousand square miles with well exposed sections, the absence of any deposits of coal, which are so valuable and abundant in the upper groups of the Ranigunj field, is an additional and strong reason why these rocks should be referred to the *Panchet* group rather than to the others. It might possibly solve the difficulty better in the first instance to establish an intermediate and distinct sub-division applicable only to a part of this upper group of rocks in the west, but this would perhaps only lead to greater difficulties, because this group must be localized, while all the facts point rather to a gradual passage of character over geographical areas, than to any definite sub-division. In any such large series, where the sub-divisions are not marked by material interruption, or change, of deposit, or by any long interval of time accompanied by the destruction of pre-existing beds, there is no possibility of drawing any trenchant line of division, for such does not exist. And it can, therefore, be only on a balancing of evidence that any part is placed in correlation with one sub-division rather than with another.

Mr. Medlicott has also brought forward additional proofs to show that, on the large scale, the present limits of these coal-measure fields coincide approximately with the original limits of deposition and are not the result of faulting, or even mainly of denudation.

This limitation of original deposition has long been the view held by Mr. Hughes (and by myself) with reference to the Bengal fields which he had examined, and Mr. Medlicott now shows how he considers it applicable to those in the west also.

There appear to me, however, wider and larger views of this variation in mineral character, and in succession of beds, as well as in limitation of area occupied, which must be worked out in greater detail before any definite conclusions be possible. They may, however, be indicated. All these successive beds, (possibly with the exception of the *Talchirs*) representing an enormous lapse of time, agree in one respect, that they seem to be purely fresh water (fluviatile or fluvio-lacustrine) or estuarine deposits. This fact alone involves the consideration of definite limits within which the rivers or lakes by which, or in which, they were formed were confined at the time of their deposition. This again would seem unavoidably to bring with it a very large amount of variation in each basin of deposition quite consistently with a general resemblance or agreement in the succession. It seems difficult, if not almost impossible, to suppose that coincidently with any great changes of surface level, &c., which may have affected the whole country, there were not also variations in each more limited area, or drainage basin of the then existing dry land. Thus it seems to me, we are naturally led, *á priori*, to look for a general persistence of type coincidently with a wide limit of variation in detail. And this, I believe, will go far to account for much of the variation we do find. The present distribution of these coal-fields in India, modified, as it undoubtedly has been, by the great destruction and denudation to which not only the coal-bearing, but all subjacent rocks have been subjected, appears to me to point also to this limitation to defined areas. Thus the Ranigunj, the Jherria, the Bokaro, the Ramghur, and the Karunpura fields all belong to the drainage basin of the Damoodah river. Itkuri (Eetcoora), and the Kurhurbari fields are in the basin of the Barakar, the largest affluent of the Damoodah, from which in the upper part of its course it is separated by the lofty ranges of Parasnath and the wide plateau of Hazaribagh. The Kasta deposits and the limited field near Dubrajpur and the Deogur fields are in the valley of the Adjai, and limited to it, while the valley of the More, further to the north, has its small field near to Soory. (In a wider view, all these rivers may be considered to have formed one general estuary at an early period). The Talchir field, near Katták, the detached areas of Talchir sandstones in the Sumbulpur country, and the Belaspur field, are limited to the Mahanuddy basin; the Palamow, the Singrowli, and South Rewah coals are all strictly confined to the Sone basin;—the Chanda field and the continuation of this field in detached areas down the Godavery valley, considerably below Dumagudiam, all are strictly confined to the basin of the Godavery and its affluents, while similarly the coal-fields of the Nerbudda valley are all limited to the drainage basin of that river.

In other words, it seems to me that there is very strong evidence to lead to the conviction (announced by me at the meeting of the British Association in December 1867, when speaking generally of the Geology of India), that the great drainage basins of this country were on the large scale marked out, and existed (as drainage-basins) at the enormously distant period which marked the commencement of the deposition of the great plant-bearing series to which I have referred.

In this point of view, local variations in the lithological type, and local variations in the thickness of the groups, and even their occurrence or non-occurrence, are only necessary consequences of the mode and limits of formation. And this will, I think, go far to account for these variations.

Mr. Medlicott has arrived at somewhat similar conclusions bearing on the limits of deposition of these beds as applied to some of the basins.

At the commencement of the present season, Mr. Medlicott proceeded to the Nerbudda valley, to work out more closely than had before been practicable the coal-bearing rocks in that area. When first visited, now more than twelve years since, no maps whatever existed of the Nursingpur and Hoshungabad districts, and it was necessary, in order to obtain any record, to carry out a general topographical sketch or survey concurrently with the geological examination. Within the last few months we obtained the finished revenue survey maps of these districts (Hoshungabad and Nursingpur), and I have at once taken advantage of them to ascertain with greater accuracy than was originally possible the distribution and contents of the coal-measure rocks there. The approaching completion

of the line of railway between Jubbulpur and Bombay also rendered it urgently important that this should be done at the earliest date.

Mr. Willson examined in the early part of the year a large portion of the Jhansi and Lullutpur districts, tracing out the remarkable quartz reefs that exist in such numbers and of such size in that area, and mapping with care the limits also of the recent deposits. And he is at present engaged in the continuation of this work, so as to join on his geological boundaries with those already very carefully put in by himself in the Saugor and Dumoh districts and with those in the Gwalior country mapped by Mr. Hacket.

The terrible sufferings of the population in Jeypore and adjoining country from failure of their crops, and the consequences of deficiency of food, rendered it desirable that Mr. Hacket should not return for the present season to the work on which he had been there engaged. He has, therefore, been moved to Jubbulpur, where he will carry out the examination with the detailed maps now available of the south-east portion of the district, and connect it with Rewah to the north and east. In the beginning of the year Mr. Hacket traced out the boundary of the great Deccan trap area, from Neemuch across to the Beeas river, which line has since been embodied in the general map of the Vindhyan area accompanying the published report of Mr. F. Mallet.

Mr. Ball, in the early part of the year, carried out the examination of parts of the Singhbhum country, tracing out carefully the copper-bearing rocks and their limits. And since Mr. Ormsby's return in the autumn, Mr. Ball and Mr. Ormsby have both been sent to revise and bring up to the existing state of knowledge of Indian Geology the maps of Bhagulpur and Birbhum previous to final publication. These districts were among those earliest examined in this country. And since that time very considerable progress has been made in the distinguishing of the rock groups of India. The original examination of these districts had also been more than once necessarily interrupted by disturbances among the Sonthals and other causes, and it was therefore essential that they should be gone over again with a view to general revision.

Mr. Mallet, during the early portion of the year, was engaged in working out in detail, and with the advantage of new and better maps, the relations of the several groups of rocks which occur in the eastern portion of the Sone valley, and which there come between the Vindhyan formation and the gneissose rocks. The more important of his results have been embodied in the Report on the Vindhyan formation, published during the year, which is noticed further on. Mr. Mallet, as already mentioned, has obtained leave for one year, and left India in September.

Mr. W. Blanford rejoined the Geological Survey on his return from deputation as Naturalist and Geologist in connection with the Abyssinian Field Force at the beginning of November. He has taken up the careful examination of the Chanda district with the assistance of Mr. Hughes and Mr. Fedden. Of this district he had himself made a rapid reconnoissance in 1866 and furnished a sketch geological map, which, considering the very unfavorable nature of the country for any geological examination and the brief visit Mr. Blanford paid to the district, was marvellously accurate and good. Mr. Blanford then also was the first to realize the true nature of the coal deposits of the field, which had been searched out with untiring determination by Major Lucie-Smith, the Deputy Commissioner. The occurrence of these coals in this district in a geographical position singularly favorable for the supply of fuel to a very large area both to the west and south, and the considerable difficulties attending the investigation, rendered it highly important that the facts should be ascertained as quickly as possible. I have therefore moved up from Bengal Mr. Theod. Hughes, who has perhaps had more experience and detailed knowledge of the Indian coal-bearing rocks than any one on the Survey, and with Mr. Fedden he will act under Mr. Blanford, Deputy Superintendent. The work was allotted without delay. Mr. Blanford himself, in addition to the general supervision of all, has taken up the detailed investigation of the rocks which come below the coal measure series. Mr. Fedden has been sent to those above the same series, while Mr. Hughes will take up these coal-rocks themselves. The district is most unfavorable for detailed geological examination, being either more than usually covered with very thick deposits of clays and gravels (often cemented into a hard calcareous conglomerate), occasionally containing bones or fragments of bones of large animals, and all probably of the same general age as the similar conglomerates of the Nerbudda and Godavery valleys, *(Pliocene)*, or

concealed by widely spreading jungles and forests often almost impenetrable. Mr. Blanford years since pointed out that it would be impossible to arrive at any satisfactory conclusions without actually boring in many places, and this actual testing of the ground is now being carried out successfully in conjunction with the general examination. Should the officers of the Survey be fortunate enough to preserve good health during the season, this year will see a large area thoroughly explored. As already mentioned, the late rains in October produced a good deal of fever and illness, and, as usual, the Survey parties have also suffered.

MADRAS.—The early part of the year (1869) was given by Mr. King and Mr. Foote to the completion of the geological area occupied by quartzites, slates, limestones, &c., which cover the larger portion of the districts of Kuddapah and Kurnool, and which appear, geologically, to represent in the south the older portion of the great Vindhyan series, to which allusion has already been made. This great area being complete in itself, that is, being surrounded on all sides by rocks of totally different ages and different mineral characters, will be treated of as one. And since the close of the field work, Mr. King has completed a general report on the entire area containing many thousand square miles. This report is now in preparation for the press; and will be issued during the present year. Mr. King took furlough-leave in September, handing over the Madras work to Mr. Foote. For the present season Mr. Foote has been directed to carry on the examination of the rocks, of the same mineral character, which appear under the great flows of the Deccan trap, and resting quite unconformably on the gneiss rocks in parts of the Raichoor Doab, the vicinity of Belgaum, and under parts of the ghats on the western coast. That they belong to the same general series as the rocks in Kuddapah and Kurnool there is no question, and it is hoped that Mr. Foote's acquaintance with the latter will enable him the more easily to identify them. This will connect with the Madras area the work already done by Mr. C. Wilkinson some years since in Rutnagherry and Sawunt Warree, but which was unfortunately left unfinished, when that gentleman was obliged to resign his connection with the Survey, as his health could not bear the great exposure unavoidably entailed by his geological work. This work will also, I think, give us a second complete section (geological) across the Peninsula.

I have had occasion already to notice the decease of Mr. C. Oldham, which untimely event, and Mr. King's absence on leave have reduced the Madras party for the present season to only one, Mr. Bruce Foote.

BOMBAY.—The Bombay party of the Survey continued the examination of Kutch as reported last year. This was completed before the close of the working season of 1869, and Mr. Wynne and Mr. Fedden both deserve much credit for the zealous and earnest spirit with which they carried out this work in a very difficult and in many ways very inaccessible district. Mr. Wynne has subsequently, during the monsoon, prepared a very admirably executed map of the whole of Kutch, and has embodied his own and Mr. Fedden's researches in a general report, accompanied with many excellent and well-drawn sketches. This map is on the same scale as the Atlas of India, namely, 4 miles = one inch, and it will scarcely be practicable to show the detail of the geology on a smaller map, although the publication of this large plan will be difficult.

At the commencement of the present season, as soon as it was practicable to leave Kutch, Mr. Wynne proceeded, as ordered, to the Punjab to take up the detailed examination of that province, while Mr. Fedden proceeded to Bombay, and joining Mr. Blanford took up, under his instructions, the examination of parts of the Chanda and Woon districts, in which he is now engaged.

It had long been my desire to carry out a careful examination of the Punjab, which offers to the Geologist many points of great interest, as well as promise of valuable mineral products. But the pressing demands for geological enquiry in other directions have always hitherto prevented any of the staff of the Survey from being located there. It was, therefore, with pleasure that I found it practicable to send Mr. Wynne there this season, and I doubt not he will exhibit the same zeal and ability there as he has elsewhere. I have asked his special attention to the relations of the beds from which petroleum is obtained or likely to be obtained.

BURMAH.—Mr. W. Theobald has, as anticipated in last year's report, completed the general examination of the Prome district up to the frontier of British Burmah, so far as that lies to the east of the Irawadi. He has this season taken up the country lying to the west of the river in the same parallel, and I hope the season will see it completed. In this

part of the district, nummulitic rocks (limestones, &c.,) occur and form an interesting study. They may be found to contain petroleum, as they occasionally do elsewhere.

PUBLICATIONS.—The first part of the seventh volume of the *Memoirs of the Geological Survey of India* contains a full report on the area occupied in North-Western India by the great series of rocks, to which the name VINDHYAN was first given by myself in 1856. Stretching along the northern escarpments of the Nerbudda valley, passing across the district of Jubbulpur, and forming the whole of the Rewah country north of the Sone, this great series extends in a continuous mass far into Bengal, where the picturesque cliffs of the Rhotasgurh hills form its steeply scarped limits on the left bank of the Sone. Returning towards the west by Sasseram, Chunar, Mirzapur, and a little south of Allahabad, the boundary thence stretches in a great sweeping bay or curve to the south by Kirwee, Bijawur, and crossing the Beas river, trends again north to Gwalior and Agra, and Futtipur Sikri, whence the line again trends to the south and extends to near Neemuch. The rocks belonging to this widely extended and important group constitute one of the most remarkable and interesting series in all India. They become also still more important to the Indian Geologist when he finds representatives of the same great series covering immense areas in the Madras Presidency (Kuddapah, Kurnool, &c.), stretching northwards along the flanks of the ghats, and up the Godavery country, until in Berar and the adjoining parts of the Nizam's dominions, and again in Bustar and Chutteesgurh, they constitute the rocky basis of very extended districts. They are divisible into several different groups characterized by peculiar lithological distinctions, and throughout the whole area described present a wonderful constancy of mineral composition. Mr. Fred. Mallet, who had himself examined much of the area in N. W. India occupied by these rocks, has combined with his personal observations the labours of others, and has given a connected history of the entire series in this part of the Memoirs.

I have always found it exceedingly difficult to lead to a just conception of the immensity of the areas we have to deal with in this country. And it may be useful to draw a comparison here which may tend to a realization of the facts. The small map, which accompanies the report of Mr. Mallet, (a reduction from the larger scale maps used in the field) just noticed, represents an area quite as large as England and Wales; while all the lines of geological division and sub-division shown on it have been actually traced out by detailed examination. The previous part of the *Memoirs*, the last part of Volume VI, contained also a geological map of quite as extended an area, that is, geological maps and reports have been published within twelve months, exhibiting the structure of a country larger in area than the whole of Great Britain and Ireland. And it should be added of a country regarding the structure of which nothing trustworthy was known previously to the commencement of the Geological Survey.

The same part of Volume VII contains also a continuation for 1868 of the annual returns of the quantity of COAL raised in India in continuation of similar returns which I had already published for the years since 1857. The full details will be seen in the tables given.

There is also, in the same part, a careful description of the very interesting area near Cherra Poonji in Eastern Bengal by Mr. Medlicott. As stated in my last report, Mr. Medlicott enjoyed the advantage of visiting these hills at the only time of year in which it was possible for any one, without certainty of serious illness, to visit the lower valleys, which are deadly in the rainy season. He has thus been able to clear up much that was unknown, and the consequence has been a considerable modification of the views originally taken of their structure. Mr. Medlicott has also been able to carry out the separation of the tertiary and cretaceous rocks, the necessity for which, as established by fossils, was indicated by me in 1863, (Quar. Jour. Geol. Soc., Lond. vol. xix, p. 524). His brief memoir will prove a valuable basis on which to carry out the detailed examination of the adjoining hills.

Reports on the Kurhurbari coal-field and on the detached and small fields near Deoghur in Birbhum are ready; their issue being only delayed by the time required for colouring the geological maps.

Of the *Palæontologia Indica*, a part or fasciculus of which was due in October last, I have not issued any part. Several complaints as to the loss and injury sustained in consequence of the issue of this valuable series in small fasciculi having reached me, and desire

having been expressed that they should be sent in larger parts, or volumes, or half volumes I have thought it better to defer the issue for a little until a larger part can be published at once. The four parts, therefore, for the year 1869-70, the last of which will be due in October 1870, will be issued during the year before October, and will constitute half a volume. The plates for all these are quite ready, and separate fasciculi could be issued now, but, for the reasons here given, it is thought wiser to delay a little and give four parts in one, as was done before.

The *Records of the Geological Survey*, which, as announced, are intended to convey a notice of the current work of the Survey, shorter papers, and abstracts of papers which cannot be published in detail at once, with analyses of works bearing upon the Geology of India, have punctually appeared at the stated intervals of three months. In the numbers for the past year, we have given to the public descriptions of the geology of the rich and productive valley of Berar; sketch of the Geology of Kutch; of the Shillong plateau (since published in detail); of the Kuddapah and Kurnool districts in Madras, (of which detailed report is in press); on parts of Prome in British Burmah; on the general relations of the metamorphic rocks of Bengal; in palæontology, a careful description and plate of the fossil *Pangshura* (*Emys*) *tecta*, and other *Chelonia*. These are of very high interest, as they are truly identical with the same species, now living abundantly in this country, while the remains described were found along with remains of animals which have long ceased to exist in India, (*Hippopotamus*, *Sivatherium*, *Mastodon*, *&c.*). Bearing on the practical applications of Geology, we have notices of gold in Singhbhum; of the mineral statistics of Kumaon, where a considerable amount of copper is still raised by the inhabitants; and on the coal-fields of the Central Provinces: while to meet the general interest excited in the history of the Nicobar Islands, and to answer many enquiries made regarding their geology, I have published a translation of the most recent and valuable contribution to their geological history, which having appeared in German, as a part of an expensive and not generally available series of publications, containing the researches of the scientific expedition which the Austrian Government sent round the world in the "Novara" (1857-59), was not accessible generally to the public here. Full lists of the additions to our library here, of which so large a portion consists of exchanges with scientific institutions and societies in other countries, are also regularly given in the *Records*.

In addition to the ordinary current work of the Survey much additional labour has been undertaken in furnishing brief notices or sketches of different districts or provinces for district officers, and lately more especially for the officers charged with the editing of the several Gazetteers now in preparation. These notices are necessarily required to be brief, but the briefer they are, the more time and trouble they cost. I have further undertaken to continue to supply these notices from time to time, not only for Bengal, but for other parts of the country. Copies of geological maps, and sketch geological maps have also been given to several public authorities and others, who have been interested either in investigations connected with the mineral resources of the country, or for sanitary purposes. Of the value and utility of these maps, we have received cordial acknowledgments from all.

LIBRARY.—During the year just past, 883 volumes or parts of volumes have been added to our library. Of this number 393 were presented by other institutions or societies, or were received in exchange for the publications of the Geological Survey. A full list, as already mentioned, is given of the additions every three months in the Records. As usual, a list is here appended showing all the societies or public institutions from which donations or exchanges have been received during the year 1869.

As with the collections, so also with our books, maps, &c., we are most seriously inconvenienced by the very limited space available for their exhibition or preservation—a difficulty which there is at the present no means of obviating.

MUSEUM.—So far as there has been any room, additions have constantly been made to the collections exhibited in the Museum; and all practicable means are adopted to prepare other series for exhibition, whenever it may be possible to accomplish this. More than 20,000 specimens have passed through the Curator's and Assistant Curator's hands, and have been entered and catalogued for reference during the year. But many of these had to be packed up again, there being no place to keep them otherwise. Cases have been procured as quickly as possible for the additional rooms noticed in last year's report, but they are not all ready yet.

METEORITES.—Our noble collection of Meteorites maintains its excellence. During the twelve months past, we have had additions of a good specimen of the Khetree fall (February 1867), for which we are indebted to Mr. D. Waldie of Calcutta, and specimens of the Ornans fall (July 1868); of that which occurred at Sclavetić in Croatia (May 1868); and of the mass which fell at Krähenberg, near Zweibrücken (May 1869). For the last three we are indebted to Dr. Tschermak of the Imperial Mineral Cabinet at Vienna.

As customary, an Index map, on a small scale, is appended, showing roughly the present state of progress of the Survey; as also a list of those societies or public institutions from which we have received publications, during the twelve months, in exchange for those of the Geological Survey of India.

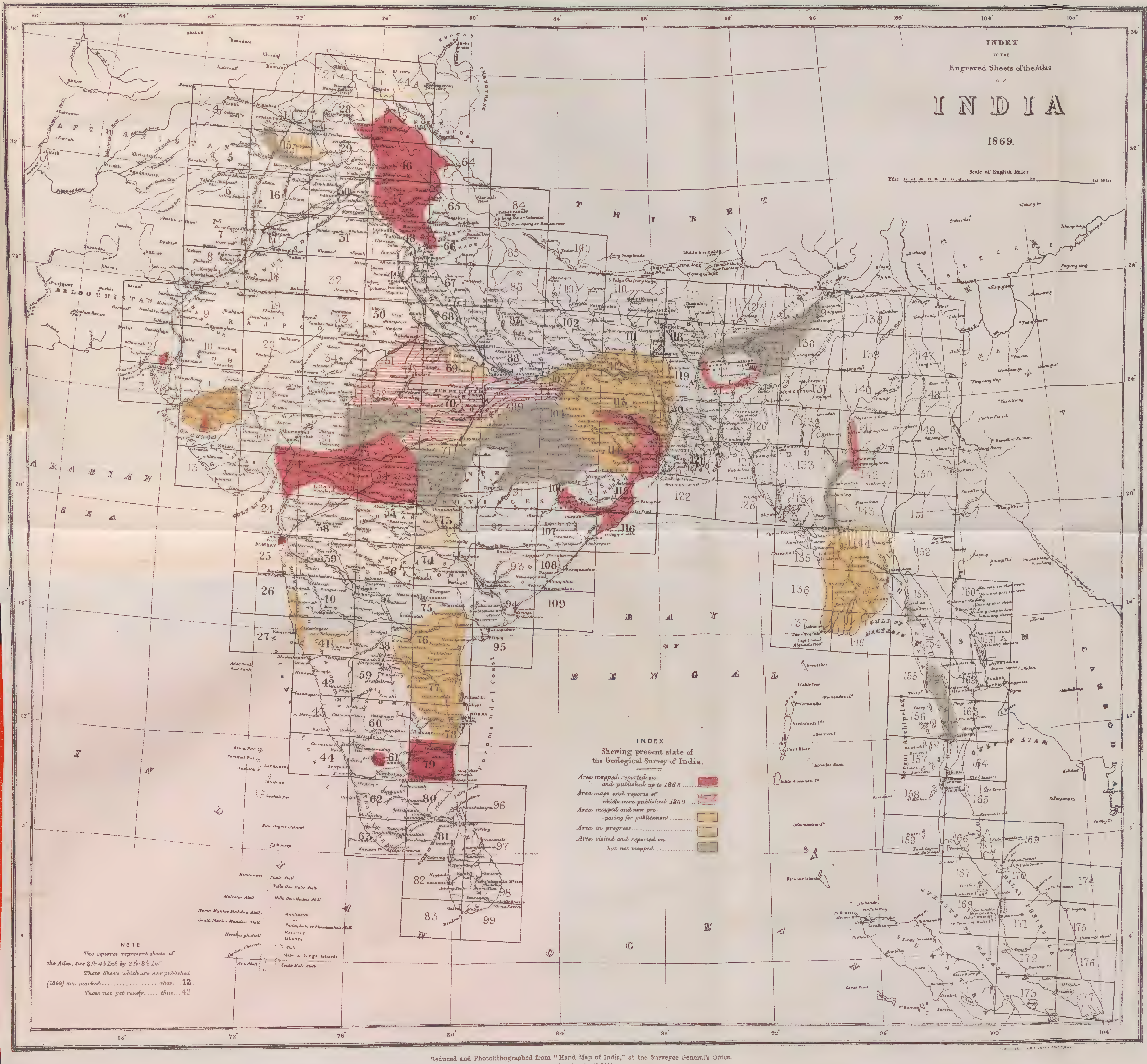
T. OLDHAM,

CAMP, CHANDA DISTRICT, *January 3rd*, 1870.

Supdt. of Geol. Survey of India and Director of Geol. Museum, Calcutta.

List of Societies and other Public Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1869.

BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Academy of Science.
„ Deutsche Geologische Gesellschaft.
BOMBAY.—Geographical Society.
BOSTON.—Society of Natural History.
„ Museum of comparative Zoology.
BRESLAU.—Schlesische Gesellschaft für vaterlændische Cultur.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Indian Annals of Medical Science.
CORNWALL.—Royal Geological Society.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Society.
„ Royal Geological Society.
EDINBURGH.—Royal Society.
GÖTTINGEN.—Königl. Gesellschaft der Wissenschaften.
HALLE.—Natural History Society.
JUBBULPORE.—Government School of Industry.
LAUSANNE.—Société Vaudoise des Sciences Naturelles.
LONDON.—Royal Geographical Society.
„ Royal Society.
„ Royal Asiatic Society of Great Britain and Ireland.
„ Geological Society.
„ Geological Survey of Great Britain and Ireland.
„ Society of Arts.
MADRID.—Royal Society.
MANCHESTER.—Literary and Philosophical Society.
MOSCOW.—Société Impériale des Naturalistes.
NORWAY.—Royal University of Christiania.
PALERMO.—Scienze Naturali ed Economiche.
PARIS.—Academy of Sciences.
„ Comm. des Annales des Mines.
„ Société Géologique de France.
PHILADELPHIA.—American Philosophical Society.
„ Franklin Institute.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Essex Institute.
TORONTO.—Canadian Institute.



Reduced and Photolithographed from "Hand Map of India," at the Surveyor General's Office.
Calcutta, April 1869.

TURIN.—Royal Academy of Sciences.
VICTORIA.—Royal Society.
 „ Philosophical Institute.
 „ Govt. Geological Survey of Victoria.
VIENNA.—Kais. Akad. der Wissenschaften.
 „ K. K. Geologische Reichs-Anstalt.
WASHINGTON.—Smithsonian Institute.

Governments of India, Madras, Bombay, Bengal, N. W. Provinces, Punjab; Chief Commissioners, Oude, Central Provinces, British Burmah.

NOTES ON THE GEOLOGY OF THE NEIGHBOURHOOD OF MADRAS,—by R. BRUCE FOOTE, Esq., F. G. S., Geological Survey of India.

The greater part of the Madras district lying north of the Palar river and south of the Pulicat lake is occupied by rocks of the secondary, tertiary, and recent ages, the remainder of the area being taken up by metamorphic rocks forming part of the great gneissic series of Southern India.

The topographical features of this part of the Carnatic are very simple, the ground rising from the coast westward up to the foot of the Eastern ghâts and their outliers, in a very gradually inclined plane which I will call the Madras area. The surface of this plane is varied only by the shallow valleys of the Narnaveram, Cortelliar, and Palar rivers, the latter forming the southern boundary of the tract of country now under consideration. In the north-western part of the district the inclined plane is broken by two groups of hills, the Sattavedu and Alicoor hills, to the west and north-west of which, but just beyond the boundary of the country now to be described, rise the Naggery mountains, which are lofty and conspicuous, but perfectly detached outliers of the Eastern ghâts. The south-eastern corner of the inclined plane is dotted by a number of low, but picturesque, ridgy gneiss hills.

The northern, central, and south-western parts of the Madras area are occupied by the stratified rocks, roughly speaking, the southern and south-eastern parts by the metamorphic rocks, a narrow belt of which must be included all round the western boundary of the area of the stratified rocks.

CLASSIFICATION OF THE ROCKS.

The following tabular statement illustrates the various groups into which the rocks of the Madras area have been classified:—

Recent or quaternary ...	Blown sands. Alluvium, marine, and fluviatile. Laterite and Conjeveram gravels.
Tertiary	Gritty sandstones. ? Cuddalore sandstones.
Secondary	(Cretaceous ?) Jurassic, Rajmahal plant beds.
Submetamorphic ...	Cuddapah group.
Metamorphic	Gneissic series.

The Blown Sands.—These sub-aerial deposits are of no great extent or importance, as they form merely a fringing ridge to the beach. To the south of Madras they are largest at, and to the south of, Covelong (Kovilam of the natives). North of Madras they attain their greatest height, between 40 and 50 feet, at a place called Chintamanikovil, where they have nearly covered up the Kovil (Hindu temple).

The greatest width attained by this coast ridge may be about a mile, but it is generally much less, and the amount of drifting inland is not of any real importance, and easily stopped by plantations of suitable trees, *e. g.*, Casuarinas, Palmyra palms, Screw pines, and Cashewnut trees, all of which flourish near the coast.

The alluvial formations.—These are of two classes, marine (including estuarine) and fluviatile, but they are nearly undistinguishable in character, and at many points graduate into each other imperceptibly.

Their general character, as seen at the surface, is that of pure, or nearly pure, silicious sands, but beds of black, blue, or grey clay occur largely below the surface in the marine alluvium near Madras; these are, however, much less frequent in the fluviatile alluvium higher up the river valleys. The greatest depth to which the marine beds have been pierced by sinkings is 55 feet, when the gneiss was reached. In the marine and estuarine beds along the coast many of the clays are largely filled with shells, all of living species, but in a sub-fossil condition. Such marine beds are known to extend two to three miles inland, but I could not ascertain whether they had been penetrated by any sinkings further inland.

The river alluvia are of more interest than the marine, because they afford evidence of some remarkable changes within the human period in the courses of several of the principal rivers in the district. Lithologically, the fluviatile alluvia are of no interest, for they consist, as a rule, of nothing but coarse, gritty, loose, silicious sand. Gravels or clayey beds are rare, and organic remains are hardly ever met with, excepting a few *Helices* and fresh water shells, (all of living species), in thin beds of reddish loam.

The changes in the course of the rivers above referred to are four in number, and concern three rivers, the Palar, the Cortelliar, and the Naggery river, but I will only notice the two most important here.

The Palar now flows into the sea 42 miles south of Madras, but it, or a large branch of it, formerly flowed down what is now the alluvial valley of the Cortelliar, and debouched into the sea, somewhere to the north of Madras, probably between Ennore and Pulicat. The present Cortelliar valley is very disproportionately large as compared with the river which runs through it in a rather deep channel.

The present valley of the Palar is still more disproportionately small as compared with its river; the two alluvial valleys join, or rather diverge, at a place about 10 miles east of the town of Arcot. A stream is even now connected with the Palar just at the fork by which water is still carried down the Cortelliar valley for many miles and eventually falls into that river.

This stream is considered by the natives to be the old Palar and bears a Sanscrit name, Vridachara nuddee or old milk river, the Tamil word Palar also signifying milk river. A similar change, of course, has occurred to the Naggery river, which in former times fell into the Narnaveram river, close to the Ramaghiri mountain, at Nagloperam. The Naggery river was diverted from its old course at a place about two miles east by south of the town of Naggery, and made, by the cutting of a channel about half a mile in length through gneissic rocks, to turn to the south-east instead of flowing due east and east by north and to fall into the Trittang river, which joins the Cortelliar a few miles further east. The broad alluvial valley which now runs between the Naggery mountain ridge and the Alicoor hills is in consequence of this change drained only by small streams and artificial channels.

I could not obtain any information on this point from the enquiries I made on the spot, but from the appearance of the cut through the neck of gneissic rock above described, I think the change of the river course was the result of human agency. Like the alluvium of the Palar river the alluvia of the Naggery river (both in its old valley and along the newer channel as far as its junction with the Cortelliar) and of the Narnaveram river consist almost entirely of coarse gritty sand; clay beds are rare, but where met with are of black color and regur-like texture. All the rivers named appear to be still cutting their channels deeper and deeper every season.

Lateritic formations.—The formations classed under the above heading are of three principal kinds, namely, clayey conglomerates, gravels, and sands which occur distributed over nearly the whole of the area under consideration.

Their occurrence is, however, not so much in continuous spreads as in detached patches, many of which are but of small size, though some occupy important areas from one hundred to two or nearly three hundred square miles in extent.

These larger areas occupy, as a rule, the higher grounds lying between the different river valleys; the small patches occur at similar levels and are evidently outliers left by partial denudatory action by which the once continuous lateritic deposits have been thus broken up.

The thickness of the lateritic formations is very small when compared to their superficial extension. They rarely attain a thickness of 12 feet or upwards.

The three principal kinds of rock above enumerated which make up the bulk of the lateritic series, namely, clayey conglomerates, gravels, and sands, are found constantly graduating into each other in such a manner that they can only be regarded as parts of one and the same deposit, however various the appearance of the different members.

In the Madras area, and to the north of Madras in the Nellore district, the character of the lateritic formations is considerably different from that of the representatives of the same series further south in Trichinopoly and South Arcot districts, the difference consisting in the much greater frequency of conglomerates and in the presence of large quantities of quartzite pebbles enclosed in the conglomerates. This peculiarity depends on the proximity of the quartzite rocks of the Cuddapah series, which attain their southernmost point in the Naggery mountains, and even more perhaps on the extensive destruction of the much younger conglomerates of the jurassic series which were mainly composed of pebbles and boulders of such quartzite and were of great thickness. The laterites of South Arcot, Trichinopoly, and Tanjore, on the contrary, do not, so far as known, contain any quartzite whatsoever, but only fragments of gneissic rocks, and these but very rarely. The nearer the laterite of the Madras area approaches to the Alicoor and Sattavedu hills, which are entirely composed of the coarse jurassic conglomerate above spoken of, the larger do the quartzite and other pebbles it encloses become. In some of the laterite sections indeed near those hills the conglomerate is so coarse that few of the enclosed pebbles are less in size than a man's head, and many very much larger; some, indeed, though perfectly smooth and well rounded, of such size as to deserve the name of boulders.

In such conglomerates the matrix of ferruginous clay iron stone is almost masked by the included masses.

Near the sea, however, as at the Red Hills, a few miles north-west of Madras, the included quartzite pebbles are small and not numerous, and the conglomeratic character not everywhere visible. Where such is the case, the peculiar characteristics of typical laterite, namely, its ferruginous character, its permeation by tubular and vesicular cavities filled with pale colored sandy clay, and lastly, its hardening and becoming coated with a glaze when exposed to atmospheric influences, are seen to perfection.

The laterite gravels frequently contain pebbles of quartzite and gneiss mixed with the pisiform ferruginous pellets in varying proportion according to their proximity or distance from the older quartzite yielding rocks. The sands associated with the lateritic conglomerates and gravels show considerable variety in texture and color, the latter depending on the percentage of iron. They not unfrequently contain a large quantity of clay, and are then apt to cake and harden, but without the excessive fissuring noticeable in purer clays. These sandy beds are frequently found overlying the highly ferruginous beds and form to a great extent the soil of the laterite areas.

The Conjeveram gravels.—In the south-western part of the Madras area the high grounds north-north-east and north-west of Conjeveram are covered by a peculiar quartzite gravel formation occupying the same relative position as the true laterite further to the east and north, but distinguishable from it by the absence of ferruginous matter, and consequently by its pale color. This change in mineral character (supposing the Conjeveram gravels to belong to the laterite period) takes place a little westward of a line drawn from Wallajahbad due north to the alluvium of the Cortelliar valley, but unfortunately no section occurs showing the two formations in juxtaposition.

Both have so far proved unfossiliferous as far as true organic remains are concerned, but both appear to contain implements of human manufacture in the shape of axes and spear heads made of *chipped* quartzite pebbles and of the same types as those occurring in the gravels of Western Europe. I have given the name of the famous old town of Conjeveram to this non-ferruginous gravel deposit, from its occurring, so far as I know, only within the Conjeveram taluq.

Cuddalore Sandstones.

Underlying the lateritic formations in the northern part of the Madras district is a gritty sandstone of white or drab color sometimes slightly mottled with rusty spots. This sandstone, which is well exposed only in the cliffs on the south side of the Cortelliar river, six miles north-west by north of the Red Hills, bears a strong resemblance lithologically

to some parts of the Cuddalore sandstones as seen near Cuddalore, and like them appears completely unfossiliferous. In the Cortelliar cliffs the following section is exposed:—

Lateritic conglomerate	3 to 4 feet.
Mottled gritty sandstone	6 „
Quartzose grit of buffy white and brown colors, becoming whiter and coarser grained downwards, very friable; beds divided by thin partings of Kunkur	30 to 40 „

The base of the section is unfortunately entirely obscured by fallen masses, or by the water which here remains in a deep pool at the foot of the cliffs.

It is not known what underlies these beds, so they can only be provisionally regarded as representatives of the Cuddalore sandstones. The gritty sandstones west of Poonamallee which Mr. H. F. Blanford was disposed to refer to the same supra-cretaceous position have yielded a few fossils of unmistakeably Rajmahal (jurassic) character.

No representatives of the cretaceous group being as yet known to occur within the limited Madras area I pass on to review the different members of the

RAJMAHAL OR JURASSIC ROCKS.

Although occupying superficially a lesser area than the lateritic rocks, the Rajmahal beds are of infinitely greater geological importance and deserve considerable attention.

Like the lateritic rocks, the Rajmahal beds are scattered about over the country in a number of detached areas and patches divided from each other by alluvial valleys or by bands of overlying lateritic strata that have escaped denudation. From this broken up condition of the formations added to the absence of really good sections it is difficult and in some cases almost impossible satisfactorily to correlate the different formations occurring in several patches.

For convenience sake it will be better to consider the several distinct patches in four groups, ignoring as much as possible the intervening covering formations of younger date. It is only in the three northern of these four areas that the base of the Rajmahal beds is seen, resting on the gneissic rocks along the foot of the western flanks of the Sattavedu and Alicoor hills and of the low plateau east of the Arconum railway junction.

In the Sripermatoor area the base of the series is nowhere seen owing to the great thickness of the surface deposits. Owing partly to the peculiar shape of the ground, but still more to the general softness of the rocks and to the consequent enormous accumulations of debris covering the surface, no section exists showing the true relations of more than small portions of the Rajmahal series, which renders any stratigraphical sub-division of the entire series very difficult and uncertain. A provisional sub-division into two groups has, however, been proposed, based mainly on lithological differences.

To one group consisting of coarse well consolidated conglomerates and sandstones the name of Sattavedu group has been given, from the fact of these beds having been first studied–by my colleague, Mr. King–, in the Sattavedu hills.

The other group, consisting of shales, clays, and gritty sandstones and unconsolidated conglomerates, we have called the Sripermatoor group, from its most important members occurring under and around the town of Sripermatoor.

The Sattavedu Group.—In the Sattavedu area the entire series of rocks met with consists of alternate bands of conglomerates and sandstones many hundred feet thick. These beds extend southward into the Alicoor hills area (under the valley of the Narnaveram river) and form the eastern and loftier half of the hill group. The entire eastern base of both the hill groups is covered up by lateritic conglomerates and sand, by which any extension to the east of this series is completely masked.

The chief petrological character of the members of this series is the prodigious coarseness of the conglomerates which are made up of large well rounded smooth pebbles of quartzite with a small number of similarly waterworn masses of granitoid gneiss firmly cemented together by a varying cement which is sometimes argillo-ferruginous, ferrugino-arenaceous, or silicio-calcareous. In some of the sandstone beds in the Sattavedu hills Mr. King discovered the few plant remains, amongst which was part of a recognizable *Dictyopteris* frond, proving the true Rajmahal character of the beds which contained it. In the southern extension of the

same beds in the Alicoor hills no fossils were found. The sandstones are mostly rather gritty in texture and only occasionally sufficiently compact to be useful as building stones.

Sripermatoor Group.—Apparently underlying these Sattavedu beds in perfect conformity are certain conglomerates, gritty clays and shales which form the western and southern parts of the Alicoor hills, and which differ from the beds of the Sattavedu series in being soft and quite uncompacted and of white or grey instead of brown and reddish colors. Even the coarsest conglomerate beds at and near the base of the series are soft, the pebbles and boulders of quartzite and gneiss, instead of being bound together by some firm cementing material, merely lie imbedded in a very friable, more or less clayey, grit consisting of quartzose debris derived from the gneissic rocks. Flanks of the hills consisting of these unconsolidated rocks are deeply covered by debris which is cut through by only a few rain-gullies of recent origin, and it is these only which afford sections of the undisturbed rocks. Many of the gullies, however, do not even cut through the thick coating of debris and rain wash. No section was found showing these unconsolidated beds in contact with the consolidated Sattavedu beds where they approach each other in the centre of the Alicoor hill group, but as far as the rounded outlines of the hills at that point serve to guide the eye there is an undoubted dip of the softer beds under the hard conglomerates of the Sattavedu series. No sign of any fault between the two series could be traced, but a fault might well exist and yet be perfectly masked by talus and debris. The nearest visible point of approach of the two series is a short narrow east and west ridge abutting at right angles against the hard basement-conglomerate bed of the Sattavedu series, which bed here forms a prominent north and south ridge, succeeded to the eastward by several other ridges, corresponding to as many great conglomerate beds. The valleys running down north and south from the cross ridge above mentioned are the two principal valleys in the central mass of the hill group, and the depth to which they are excavated is due to the greater softness of the underlying beds as compared with the overlying series. The southern part of the Alicoor hills, called by the natives the Naikenpolliam hills, is apparently composed only of the unconsolidated beds which have trended in the direction of their strike from north and south to west-north-west and east-south-east.

The basement bed at the south-west of the Alicoor area near the village of Naikenpolliam contains included masses of conglomeratic quartzite of such tremendous size—800 to 1,000 cubic feet in bulk—that they suggest the idea of their being the relics of the basement bed of the Cuddapah rocks, which are so splendidly represented about eight miles to the north-west in the tremendous cliffs of the Naggery ridge, parts of which have a vertical face of 1,000 feet high.

Glacial agency being inadmissible in so southernly a latitude, except on exceedingly strong evidence, the only probable explanation remaining is the one above suggested, which derives great probability from the fact that, on a far smaller scale indeed, similar masses of gneiss are included in situ in the basement bed of the Rajmahal plant beds at Ootatoor and elsewhere in the Trichinopoly district. These great quartzite masses, it is true, are not seen to be resting on the gneiss surface, but the latter can only be a few feet further down the slope. The inclusion of gneiss blocks in the basement bed of the Rajmahal series is to be seen only a few miles to the south in the banks of the Naggery river at Chittapuram. Numerous plant remains of unquestionable Rajmahal species were found in the principal section at the south-west end of the Alicoor hills. Amongst these plant remains were parts of *Tæniopteris*, *Dictyopteris*, *Palæozamia*, and *Pterophyllum*, and *Poacites*-like stalks.

Unfortunately from the friable nature of the clay bed in which they occur the majority appear to have become unrecognizable in drying, though when freshly extracted from the matrix even the most delicate venations and nervures were plainly visible.

On the south side of the Naikenpolliam ridge the lower members only of the series appear to be represented; they consist of unconsolidated conglomerates of various degrees of coarseness, gritty sandstones and micaceous sandy shales, exposed in a few streams and a great many well sections.

The only section which yielded fossils was one on the north bank of the Naggery river opposite to Chittapuram, where two beds of rather friable sandstone were found to contain plant remains, amongst which fragments of *Tæniopteris* and *Dictyopteris* were identifiable.

On the opposite side of the river in the Pyanoor area the same beds reappear, and are there seen to be very low down in the series, in fact only a few feet above the basement bed,

which here includes, or rather is deposited around and among, sundry large masses of syenitoid and gneissic rock. These sandstones with micaceous shales and sundry conglomerate beds of the usual unconsolidated type extend hence throughout the Pyanoor area, as proved by the numerous well sections, which everywhere pierce the superincumbent lateritic conglomerate.

The connection between the beds occurring in the Pyanoor area and those lying within the Sripermatoor area, 12 miles to the south-east, is not clear owing to the difference in petrological characters and to the insufficient evidence afforded by the organic remains. As far as the relative topographical position of the two areas affords any clue it is in favor of the beds of the Sripermatoor area, being simply an extension of those in the Pyanoor area, the difference in mineral character of the respective beds being probably due to the more littoral character of the Pyanoor beds as compared to the Sripermatoor beds, which though not to be considered as deep-sea deposits, yet appear to have been formed at considerable distance from the land of the period. This view is favored by the lithological character of a small series of Rajmahal beds exposed in a section lying about half way between the Pyanoor and Sripermatoor areas.

The most important member of the series in the Sripermatoor area is a white shale, the plant bed *par eminence*, resting on whitish friable gritty sandstone, which is in all probability the basement bed over a great part of the area. In the southern part of the area there is another series of grey clays, reddish sandstones, and buff sandy shales, whose position with reference to the plant-shale could not be ascertained in the absence of any section showing the two series.

The area occupied by the plant-shales is, roughly speaking, a rectangular basin about eight miles long from north to south by four from east to west, formed by the junction of several shallow valleys sloping very gently eastward. Several low hills rise out of the basin and are capped with laterite. The town of Sripermatoor stands in the north-west corner of the basin, which is surrounded by rising ground, the edge of which is here and there slightly scarped. To the south-east, however, a mere roll of the ground occurs much obscured by surface soil, and beyond this the grey clays appear. The plant-shales are apparently continuous all over the basin-like area, and appear to form only one bed which rolls about very slightly at low angles, or is horizontal. The shale is white, pale-grey, or buffy-drab in color, with in one or two places a little reddish or purplish mottling. The plant remains occur scattered through the mass in a fragmentary condition, as if they had been torn off by stormy winds and then drifted out to sea. In many places they are mixed up with remains of marine animals, *e. g.*, at Amarambode and Valerie.

The richest collections of fossils were made in the north-east corner of the basin where the two sections above named yielded specimens of nearly every species in the Rajmahal beds of the Madras area. In the western part of the basin animal remains were rarely found, indeed plants were everywhere more frequent than animal remains. Of the plants several species have been recognized as identical with species from the Rajmahal beds of Bengal and Cutch. These are *Palæozamia Cutchensis* and *acutifolium* and a *Dictyopteris*. The following genera of plants appear also to be represented among the specimens collected by myself: *Taxodites (?)*, *Pterophyllum*, *Tæniopteris*, *Stangerites*, *Pecopteris*, *Lycopodium (?)*, *Poacites*, and parts of exogenous stems perfectly silicified.

The animal remains which I discovered and collected included a considerable number of bivalve shells which, according to Dr. Stoliczka, belong to the genera "*Leda*, *Yoldia*, *Tellina*, *Psammobia*, *Lima*, *Pecten*, *&c.*, all forms with a remarkably thin shell, and the allies of which are usually found living on sandy ground in from eight to ten fathoms of water. Several exhibit a resemblance to species from the cretaceous rocks of Trichinopoly, but *none* appear to be specifically identical".*

Besides the above were several small *Ammonites* referred by Dr. Stoliczka to the "*Dentati*" group (but unfortunately not sufficiently well preserved for specific identification); one a singular conical chambered shell, (? a phragmocone) of apparently cephalopodous origin, and some fish scales.

* See 'General results from an examination of the Gastropodous fauna of the South Indian Cretaceous deposits, by Ferd. Stoliczka, Ph. D., F. G. S., Palæontologist, Geological Survey of India, page 59, in Vol. I of Records, Geological Survey of India.

Reference has already been made to the different lithological character of the rocks occurring in the southern part of the Sripermatoor area and to the absence of sections by which to determine the relationship of the two sets of beds. The series of beds here met with consists of white, grey-buff and black sandy clays, and brown, buff. reddish-purple and white gritty sandstones. One of the pale-buff sandy clays contains remains of *Palæozamia* and *Stangerites.* None of the sections show the base of the series. From its topographical position and petrological character I am inclined to think that this series underlies the great "plant-shale" bed.

Of very similar character and probably occupying the same relations to the "plant-shales" is a series of gritty sandstones and shales exposed in a fine section made by an artificial channel running into the great Chumbrumbaucum tank on its north side. As this section lies two miles outside of the Sripermatoor area and the intervening space is obscured by the laterite, the position of the series here seen relatively to the "plant-shales" can only be guessed at. The Rajmahal character of these beds is proved by the finding of a fragment of a *Dictyopteris* in one of the lower beds of shaley sandstone.

To the south-west of the Sripermatoor area the Rajmahal series appears to extend to some four miles beyond Conjeveram, for shaley and sandy beds of precisely similar character underlying the Conjeveram gravels are to be seen in several well sections. The most westerly point at which unquestionably Rajmahal plant remains were found was one mile to the south-west of Rajah's Choultry.

In conclusion I may point out that these Rajmahal beds of the Madras area contrast in several respects with those of Bengal and Cutch. The Madras Jurassic, or Rajmahal, beds contain no carbonaceous matter, which in their equivalents in other parts of India occurs so largely as to form coal seams. Nothing but silicified wood has been found in the Madras beds, and unlike the Bengal beds, in the Rajmahal hills, with their great intercalated trap flows and the Cutch beds, which are overlaid by trap flows of tertiary age, the Madras series is nowhere penetrated by, or overlaid by, igneous rocks of any kind, nor in the least degree metamorphosed. Another contrast, but of less importance, is, that unlike the Cutch beds, which are often of gay and bright colors, the Madras beds are remarkable for the dullness and sobriety of their coloring, a remark which applies also to their representatives in the Trichinopoly and Nellore districts.

The Submetamorphic and Metamorphic Rocks.

These demand hardly any notice in this place. The younger or sub-metamorphic series—the Kuddapah group—does not come within the area treated of, except in one, and that possibly a doubtful case (see page 11). The metamorphic rock series—the gneiss of Southern India—also presents little of interest locally; near the coast it consists of alternating bands of quartzo-felspathic and hornblendic beds which run to some extent parallel with the coast line. Further inland to the westward of the laterite and Rajmahal areas, the gneiss is more highly crystalline and largely granitoid or syenitoid in structure, and is traversed by a few trap dykes intruded prior to the deposition of even the Kuddapah rocks.

On the alluvial deposits of the Irawadi, more particularly as contrasted with those of the Ganges,—by Wm. Theobald, Junr., Esq., *Geol. Survey of India.*

It may fairly be presumed that the origin and growth of those extended alluvial deposits, forming the plains through which the more important rivers, carve their way to the sea, were, in each several case, very similar, and that the history of the deposition of the "loess" of the Mississippi valley was but little different from that of the "loess" of the Rhine. Each river system of course has its particular history, recorded in the alluvial deposits of its basin, which, in some cases, afford a simple, in others an intricate, record of the geological vicissitudes the area has undergone, and in tracing this record we are not unfrequently brought in contact with problems far more intricate and extensive in their bearing, than the apparently uninteresting character of the beds would suggest, and we have here in India in the "loess" of our larger river basins, the same phenomena to account for which have so exercised the ingenuity of Geologists in the case of the "loess" of the Rhine

In every large river basin two distinct alluvial deposits will generally be met with, and this, though it may seem a somewhat obvious fact to lay much stress on, has nevertheless been overlooked in some instances, where its admission was necessary for the true explanation of the geology of the district. One such instance is afforded in Mr. Fergusson's paper in the Quart. Geol. Jour., Vol. XIX, 1863, where the author, from not properly grasping this fact, is betrayed into advocating a theory of elevation of the beds supporting the "Madhopore jungle" which he never would have been, had he rightly comprehended that he was dealing not with *one*, but with *two* groups of alluvial beds unconformable with each other. The older of these groups may be either $\frac{\text{marine}}{\text{estuary}}, \frac{\text{fluviatile}}{\text{lacustrine}}$, or of a mixed and alternating character, but the newer group is essentially fluvio-lacustrine, and directly produced by the existing river, albeit at one time, under surface conditions widely different from those now existing; the former of these groups I shall speak of as the older alluvium; the latter, as the "newer" or "Gangetic" or "Irawadi" alluvium, as the case may be. One essential distinction between these two groups, apart from mere stratigraphical differences, is, that whilst no very considerable thickness of the newer group can anywhere have been deposited, without a corresponding subsidence below of the area so raised at top, a very large accumulation of the older or estuary beds may have taken place, during an elevation of the area covered by them.

Under one of three conditions, every river discharges its waters into the sea, namely, within an area of either subsidence, quiescence, or elevation, and how largely, not only the character of the deposits of a large river are influenced by the prevailing conditions at the time of their formation, but the physical peculiarities no less of the delta itself, I shall endeavour to illustrate by the Irawadi, and the contrast which its delta presents to that of its sister stream, the Ganges—as these two rivers, the Ganges and Irawadi, happily furnish us with examples of rivers subjected to respectively the first and last named conditions.

In the Ganges valley the development of the *newer* or *Gangetic* alluvium properly so called (or as I would propose to restrict the term) is very considerable, and its relation and junction with the older deposits usually well defined. In the upper part of the valley it is more or less restricted to the immediate neighbourhood of the river and to the narrow limits within which the river alters its channel, but it at once spreads out on either bank over a vastly broader area than before, so soon as we descend below the confluence, on their respective banks, of the Gandak and Són; the newer deposit assuming, east of those rivers, much of the importance, as far as area goes, which the older group claimed to the west. On the north of the Ganges, in the meridian of Purneah, the newer group is thirty miles broad, which corroborates a native tradition, that that city once stood on the Ganges.*

Eastward from Purneah, in the direction of Rajshaie and Pubna, the newer deposits spread over a wide tract of low-lying country, the older clay being, however, often but a few feet below the surface, and exposed in the beds of tanks or other artificial sections. Where this clay arises from beneath the newer group, we often find it (if not usually) presenting a clearly defined boundary, giving rise to an elevated tract of country, which offers a complete contrast to the low-lying inundated land occupied by the newer alluvium—as an instance of which, I may quote the narrow strip of clay country which runs down through the newer group, and strikes the Ganges above the station of Rampore Beauliah, near Burgatchee. South of the Ganges, all round the Rajmahal hills, the boundary of the two groups is more intricate, and in some of the railway embankments a curious contrast is afforded by the difference in color of the clays belonging to different groups of which the embankment is composed, the earth at one end derived from a patch of old kunker clay being a bright reddish yellow, whilst at the other, it assumes a pitchy hue, from being taken from a bed of the newer deposit dark-colored from the accident of its forming part of the dried up bed of a

* It is possible that this estimate may require to be enlarged, but after examining the ground, I concluded that the sandy beds north of Purneah pertained to the older rather than the newer group. Though near Purneah very flat and low, they rise and undulate considerably as we approach the hills, and include pebbles gradually increasing in size as we go north (or towards the hills). The gradient of the ground, too, after passing Purneah, is *at once doubled*, going north, that of the thirty miles between Purneah and the Ganges being uniform, so that I think there are substantial grounds for holding the view I have given. The junction is, it is true, confessedly obscure, but this is the result of the sandy nature of the surface beds of the older group, which readily commingle and fuse, so to speak, with the newer deposits, the important fact of the gradient doubling along this line not being cognizable to the eye, but where the kunker clay of the older group is juxtaposed to the sands and silts of the newer alluvium the case is different and little ambiguity results.

marsh close under the hills (trap) in which spots the soil often bears no inconsiderable resemblance to the "Regur"* or dark "cotton soil" so extensively spread over Central and Western India.

If we follow the river by its most direct course to the sea down the Bhagirathi we see the last of the older deposit or "kunker" clay in the steep bluff of Rangamatia ("stained earth") over 100 miles as the crow flies above Calcutta.

Below this to the sea all is Gangetic alluvium, which at Fort William, as revealed to us by the boring operations for an artesian well, is about 70 feet in thickness, resting on the denuded surface of the kunker clay, which is clearly indicated by the "rolled kunker pebbles" strewn over it, and intersected at that depth by the bore. To consider, however, the older deposit, merely in its aspect as regards the Gangetic basin, excavated in it, is to neglect a great and important parz of its history, that is, the entire period during which the great thickness of beds under Fort William, revealed by boring, of which it constitutes the highest member, were being deposited. It is here we require to bear in mind the difference I have insisted on, between the Gangetic group proper and this older group, for there appear to me to be no such cogent reasons why we should consider these beds as "Gangetic" deposits involving thereby a depression of several hundred feet, when it seems a simpler solution equally supported by the facts of the case to regard them as estuary deposits accumulated during an upward movement of the land. The fragmentary condition of the matters brought up by the boring rod prevents any great weight attaching to the mere presence of lacustrine shells and carbonaceous matters at a great depth, as the enormous quantity of wood, vegetable trash and lacustrine shells, swept out to sea, from a tropical shore and forming in places matted rafts, must be quite adequate to leaving a lasting record in the marine strata formed in times past, no less than in those now forming in the Bay. It will hardly be contested that at no very remote period the sea bathed the southern slopes of the Himalayas and stretched from the Bay of Bengal to the Persian Gulf, and to this period during a rise of the land, and long prior to the very existence of the present Gangetic valley or drainage system, would I refer these deep-seated beds, one of the highest of which is the "kunker" clay which it has been the custom hitherto to regard as a Gangetic deposit. It may be so; but I have always held it to be marine on grounds quite independent of those suggested by the Fort William bore.

I do not, however, wish to affirm that this kunker clay which in *lower Bengal* I regard as $\frac{\text{marine}}{\text{estuary}}$ may not elsewhere prove to exhibit fluviatile characteristics, since in the upper part of the Ganges valley, say above Chunar, beds intimately connected with it, certainly afford fluviatile indications, and such variability is to be looked for in a deposit accumulated under such conditions as I have surmised; for supposing an equable elevation to take place over the whole area, still the accumulation of the coarser beds near the centres of supply of sedimentary matter, will be more rapid than that of the more remote, and they will consequently begin first to exhibit marks of fluviatile action as the sea or estuary shoals, whilst no such indications will be afforded by the others deposited in deeper water, and this appears to me a natural explanation of the fact of fluviatile beds occurring in the central and upper portion of the Ganges valley, in intimate connexion with the kunkery clay which itself nowhere exhibits any similar indications.

The reason, apart from any other considerations, which has mainly induced me to regard the old kunker clay, of lower Bengal at least, as a $\frac{\text{marine}}{\text{estuary}}$ deposit, is finding it high up on the flanks of Patarghatta hill, which rises somewhat abruptly from the alluvial plains close to the river, some few miles above Rajmahal. At the time of my visit, the clay was being worked in this position for lime, the kilns being placed near the foot of the hill for the convenience of "tipping" the "kunker" clay down to them. The occurrence of the clay at this

* An opinion I once expressed regarding the probable derivation of the "*Regur*" from the destruction of decaying trap rocks, or some crystalline rocks of similar composition, received curious confirmation during my examination of Eastern Prome. I there heard repeatedly mentioned a certain hill of "black earth" which the Burmese described as forming a curious and isolated feature in the district. Nothing like "Regur" had ever occurred to me, nor were there to my knowledge any rocks in the district, except miocene sands and clays, which did not seem likely to present the appearance described. On reaching the locality, however, I found not one only, but three isolated patches, or three separate hill tops of black earth, in every respect a veritable Regur, being the decomposed surface soil of what I at first regarded as a trap cap to the hill, but which the last examined locality convinced me was a bedded trap ash, subordinate to the beds including it, and which happened to form the summit of the three hills capped by the "black earth" in question.

high level far above that attained by the rest of the bed in the neighbourhood can only be accounted for by one of three suppositions, either that it is a capping of clay carried up *en masse* by the hill whilst being protruded up through the alluvial group surrounding it, a supposition too unsupported by evidence to merit farther examination; or that it represents a remnant of a once continuous bed of like character, which once continuously stretched across and occupied to a corresponding height, the country now forming the broad and low lying valley of the Ganges, to which also the like objection applies as to the last; or lastly it may have been originally deposited where we now see it on the hill side cotemporaneously with the rest of the bed, occupying the plains, when Patarghatta hill constituted a rock, submerged beneath the waters of that sea, which I have previously alluded to as at no distant period occupying the plains of Bengal and upper India.

Much stress should not perhaps be laid on the negative evidence of an entire absence of fossils in this clay, but had it been formed by annual increments during Gangetic floods, it is not easy to understand how in such a homogeneous clay, and one so well adapted to preserve any mulluscous remains deposited in it, no shells are found, either such as occur so abundantly in river rejectamenta; or *Uniones*, for which it must have formed in places a congenial habitat.

In the Nerbudda valley a very similar clay occurs though at a *higher level above the sea*, and though shells are not common in it, yet such shells do occur in places, as are usually swept down into inundated tracts by river floods at present, as *Bulimus pullus*, Gray, *Helix fallaciosa*, Fer. &c., as well as fine specimens of *Uniones* with valves united as in life, of species still living in the district (*U. Indicus*, Sow., and a fine variety of *U. cæruleus*, Lea.)

The above are my grounds for inclining to the belief in the $\frac{\text{marine}}{\text{estuary}}$ origin of the older alluvial clay, in lower Bengal at least, and I will close my remarks on it by briefly describing its character and appearance. Where best seen, in some steep section on the bank of the Ganges, it presents the appearance of a stiff homogeneous clay, of a mottled yellowish or pale buffish hue reddening much by exposure to the atmosphere. It contains a small amount of fine sand, the presence of which in the fields and watercourses of the newer group is an unfailing indication of an approach to the boundary of the older. Dispersed through it also are numerous small ferruginous concretions like shots, but no foreign body either in the shape of pebbles or organic remains*, have to my knowledge been found in it. In some parts, as in the colliery districts about Raniganj, where older groups of rocks cut out the alluvial deposits, gravelly beds surcharged with pisolitic oxide of iron, varying from a ferruginous gravel (in its consolidated shape termed laterite) to a bed sufficiently pure and unmixed to constitute a workable ore, occur stratigraphically subordinate to this alluvial clay, but they are mere local developments, varying in character, and influenced most probably by the nature of the rocks constituting the neighbouring country. With the exception of these gravelly, ferruginous and lateritic beds, which locally constitute a sort of bottom or junction bed of this clay, we have no knowledge of what it rests on save the rather meagre information to be gathered from the Fort William bore, neither do we know with certainty its total thickness† or if any beds superior to it in position have ever covered it, except, should my view of their relations be the correct one, the sandy beds which in Purneah and the adjoining Zillahs seem to overlie, or perhaps in part replace it; which ignorance arises from the very uniform elevation over its entire area of so thick and homogeneous a bed, and the general absence of artificial sections deep enough to pierce this.

Disseminated throughout this clay occurs the well known kunker or "gooting", occasionally in well defined nodules but more commonly in irregular stringy courses, and often so intimately commingled with the argillaceous portion of the bed, that the clay is dug in bulk for the kilns. Where this bed forms the surface of the country the more argillaceous portions are washed out, leaving the kunker strings, sheets and nodules projecting, or forming on the surface a sparse crust of "gooting" pebbles, and this is more observable in the upper portion of the valley than in lower Bengal, where the clay seems less rich in lime than to the north-westward.‡

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* Bovine bones were found in a well near Patna, at 60 feet. T. OLDHAM.

† Its thickness cannot be regarded as under 60 feet.

‡ Sir Charles Lyell, speaking of the unchanged character of this clay (Principles. Vol. I, 429.) 1,000 miles *north* of Calcutta, doubtless intends the *north-west*, &c., *above* Calcutta following the course of the river.

I cannot here enter at length on the relation of either this clay with that (the identity of which I presume) of the Jumna valley, which has yielded the as yet undescribed "Jumna fossils" (mammalian) or with the analogous fresh water deposit of the Nerbudda valley, so rich in mammalian remains, but will content myself with remarking that the difference of level between these two deposits is such, that the deposition of the one in a series of morasses fed by a sluggish river (which seems to answer the indications of the Nerbudda clay), might have gone on simultaneously with the accumulation in a shallow sea of the other of which the Rewah plateau in part formed the southern shore.

Having dwelt at some length on the older alluvium of Bengal, I will now pass to the newer deposits, or Gangetic alluvium properly so called, which will require a much briefer notice than the last. The newer or Gangetic alluvium comprises a very varied series of beds, directly precipitated from the waters of the Ganges, or its tributaries. It is at once an extensive and important group deposited within the trough excavated by the Ganges in the older clay, or filling up such low lying tracts as receive the flood waters of the Ganges during its annual inundations. It comprises some of the most fertile land in Bengal as in Tirhoot, which is styled the "garden of India" where it is largely developed, as also in Purneah, Rajshaie, Maldah, and in all the Zillahs which ntervene between them and the sea. Its mineral character is very varied from a dark silty brown to a dazzling white sand, and in the sections of the deposit exposed in the banks of the larger rivers we see nothing like the homogeneity of the older clay, but a succession of beds of different thickness and various composition, as is the normal condition of an unmixed fluviatile deposit.

It loses something perhaps of its characteristic aspect, within the tideway where the presence of tidal waters, and tidal mud, makes itself felt, but with the exception of the belt of country within the limits of the present tideway, it is essentially a typical river-deposit. About Calcutta however, though its aspect is somewhat altered by the influence of the tides, it must still be ranked as a $\frac{\text{fluviatile}}{\text{lacustrine}}$ deposit, as it contains several beds of peat clearly a marsh accumulation and sufficient to stamp its character and origin. I am aware that at Calcutta, and doubtless elsewhere within the tidal zone, oyster shells have been found and other relics pointing to marine conditions, as soondrie wood *in site of growth*, a tree which only flourishes on land overflowed by the sea, but we must presume that this deposit during the whole period of its growth, of over 60 feet at Calcutta must have been every where traversed by deep tidal creeks on the banks of which the soondrie tree flourished and in whose quiet depths oysters and other marine organisms lived, and the bore at Fort William leaves small doubt that since the epoch when the underlying older clay had been sufficiently elevated to form a tract capable of supporting vegetation, a contrary movement of depression has been going on at a rate which permits the accession of Gangetic sediment at top adequately to counterbalance the subsidence simultaneously going on below.

Let us now compare with the alluvial groups in the Ganges valley as sketched above, the similar deposits which occur in the valley of the Irawadi, prefacing the subject with a few remarks on the physical character of the country which presents some features peculiar to it, resulting from the geological structure of the delta.

The delta of the Irawadi is embraced between the Myit-ma-kha Choung, on the east, which, under the name of the Rangoon river, falls into the sea below that town; and the Bassein river on the west, which is given off as a small stream from the main river near the village of Thambyadeing, and enters the sea near Negrais Island; Elephant and Poorian Points which respectively mark the entrances of these rivers being 137 miles apart as the crow flies. The Bassein river forms naturally the most westerly arm of the Irawadi, though at its origin its size is inconsiderable; but the Myit-ma-kha Choung rises near the town of Prome, and running parallel with that stream first receives the surplus waters of the Irawadi, when flooded by channels which anastomose with it, opposite and below the village of Pouktein, 45 miles above the origin of the Bassein river; Menghee, situated between these two points, may therefore be fairly taken in our calculations as the head or apex of the Irawadi delta; on which supposition, as the distance from Menghee and Elephant and Poorian Points is respectively 129 and 176 miles, the area of the entire delta is about 12,000 square miles. By an independent calculation, I estimate the area of alluvial deposits within the delta at 11,000 square miles, as some groups older than alluvial occur within the delta, but no exact calculation can be made from the want of any, save an arbitrary boundary, of them

to the eastward, where they creep round along the Gulf of Martaban, and blend with the deposits of the Sittang valley. Proportioned thus regularly as the Irawadi delta is, as regards contour, with its three sides respectively 129, 137, and 176 miles long, it may not at once seem obvious how Mr. W. Blanford, in speaking of it, called it "a less perfect delta" than that of the Ganges. I shall, however, endeavour to show wherein it differs essentially from such delta of the Ganges, not in form, but in respect to its composition and history.

The most striking feature connected with it, is not its mere flatness, which is naturally to be looked for in such an area, but its extremely low level. No definite assertion can of course be made, but I think I am well within the mark when I say that 2,000 square miles of this tract must be below the level of a high spring tide and fully as much more not raised more than a foot or so higher. Passing through any of the creeks when a spring tide is at its height, the water is seen pouring inland up every channel and watercourse, and diffusing itself over both fields and uncultivated ground, and the conviction produced is, that a permanent submergence of a considerable tract within the delta would be the result of the water being maintained at the full height of the springs for any considerable period; as it is, however, in the course of an hour or so, the tide falls and the flooded land relieves itself through the usual channels. This extremely flat character of the country may be surmised from a mere inspection of the map, from the numerous lakes or "Engs" as they are called, scattered all over lower Pegu, and from the anastomosing and often tortuous character of even the largest river channels.

For instance, a little below the important town of Nyoung-don the Irawadi divides into two nearly equal branches, each possessing the dimensions of a first class river, one branch flowing south and discharging itself by the Dalla mouth, whilst the more westerly branch enters the sea by the Irawadi mouth. Twenty-five miles as the crow flies below the point of bifurcation of the two streams, is the small village of Tan-ta-lop Kyoung, to which I shall hereafter refer, but following the bank of the former branch or Dalla river on which it is situated, the distance is raised to 45 miles or nearly double. From the same point of bifurcation, at the same distance as the crow flies of 25 miles, on the other branch or Irawadi river is the important town of Shuay-loung; the distance to which, following the river bank, is 42 miles nearly.

Still more tortuous is the Daga river in some parts, which constitutes the most westerly channel of the Irawadi within the delta, and which, though a far narrower river than either of those above mentioned, maintains a deep and permanent channel. From the village of Shekhabyeng to the point of discharge of the Daga lake, is, as the crow flies, 18 miles, but measured along the river bank the distance actually exceeds 55 miles, which will give a notion of the extremely level character of the country it traverses—which character is not confined to the delta merely, but marks more or less all lower Pegu, save in the vicinity of the hills.

Such being the surface, character, and conditions of the delta we might not unreasonably be led to expect within it a great development of the newer or Irawadi alluvium, but so far from this being the case, the country is almost entirely composed of the older group to the almost total supersession of the newer. This will be most forcibly realised from the statement that the entire area (excluding the actual river channel) occupied by the newer or Irawadi alluvium in the valley, amounts to but 200 square miles, of which 60 miles is made up of scattered patches adjoining the river, all lying above the bifurcation of the Dalla and (Pantanau) Irawadi rivers, whilst the remaining 140 square miles constitute an isolated tract or oasis of recent deposits, below Pantanau, which seem to occupy an original trough or depression in the surface of the older group. From this it will be apparent, that with great similarity of surface conditions between the deltas of the Ganges and Irawadi, great dissimilarity exists touching their geological constitution, the newer group of alluvial deposits so largely developed in the former being, so to speak, absent in the latter. The cause of this, briefly stated, is the fact that the delta of the Irawadi at this present time is in precisely the condition of the delta of the Ganges at the time when the first layers of Gangetic alluvium, 70 feet below the present surface at Calcutta, were being deposited, and when through the single or joint action of deposition and elevation, the older marine group had become sufficiently raised to admit the deposition of beds stamped with a fluviatile and terrestrial character, and even the accumulation of such matters as peat, to permit of which the newly raised land must have been at least as high above the sea, as the better raised portions of the Irawadi

delta; since then a steady downward movement of the Gangetic delta has permitted the enormous accumulations of newer or Gangetic alluvium which covers so large an area in Bengal, whilst the future can alone disclose if any similar movement of depression will ever permit a corresponding accumulation of Irawadi alluvium in the delta in Pegu. That no such movement has taken place hitherto is clear from the absence of the newer deposits which would have originated in consequence of it, and moreover the proofs of a general elevation are, as I shall show, sufficiently clear and undeniable.

Let us now consider how far the surface conditions which obtain in lower Pegu correspond with the supposition above advocated, of a somewhat recent elevation of the country from the sea (including, in the term elevation, the accessory agent of silting up), which, be the area rising or sinking, is always going on in so shallow and protected an estuary as the head of the Gulf of Martaban. The appearance of the bed of such an estuary as that in question, would, on its first elevation above the sea, be that of a dead level regarded as a whole—merely furrowed here and there by such channels as the drainage action of the retreating waters would inevitably carve out in a plain of soft easily-removable matter. An exception to this dead level character might here and there exist either in the shape of banks of sand or other accumulations produced by currents; or depressions in the general surface produced either by the locally increased set of currents preventing the deposition of sediment or their absence altogether checking the delivery over particular localities of even the finer sedimentary particles. If we endeavour to follow the history of these suppositious depressions subsequent to their permanent elevation, and conversion into dry land, we shall thereby obtain a clue to the origin of the most prominent features at present of the Irawadi delta, *viz.*, the presence throughout it of innumerable small "engs" or lakes, the occurrence of some of different character, such as the Daga lake, and the existence of the curious isolated tract of newer alluvium, lying south of Pantanau. It is clear that in such a case as that supposed above, one of three results must happen to any depressions which the newly elevated surface may present. If the depressions are of small extent and of a shallow character, they will be converted into small lakes or "engs" in the rainy season, and be more or less dried up and converted into grassy plains, such as are commonly seen in Pegu, with a swampy navel perhaps in the centre, during the dry season. If the depression is of larger dimensions, or receives a larger supply of water than evaporation can dispose of, it drains itself naturally into the nearest or most accessible drainage channel in the country, and this appears to be the case of the Daga lake.

Should again the depression be extensive, and, as its existence might be held to render probable, it should be intersected or connected with one of the main drainage channels of the country, it will in such a case be silted up by repeated accessions of flood waters charged with sediment, and this appears to be the origin and history of the oasis-like tract of newer alluvium near Pantanau, which has all the aspect of being an extensive trough-like depression in the original surface of the land, lying in the course of two of the largest branches of the Irawadi, and in consequence speedily silted up to the level of the surrounding country by its waters.

The difference between this case and the last is one it may be said of degree, but an aboriginal difference of level, though merely one of degree, produces exactly opposite results. A moderate depression, such as the Daga lake (even *cæteris paribus* and in this case the ground surrounding it is the higher), would, during the floods, as a rule, discharge into the nearest river, whilst a greater depression, like the Pantanau trough, would, during floods, never discharge into the river, but always itself be the recipient (*till* silted up) of the waters of the flooded stream.

The Daga lake may be now briefly noticed as it forms a curious feature in the district I am describing. The Daga lake is an annular piece of water situated on the west bank of the Daga river, 25 miles north-west from Pantanau. Its shape is irregularly oval, $2\frac{3}{4}$ miles long, and varying from half a mile to a mile in width. It discharges its surplus waters into the Daga river by a short channel of about $\frac{3}{4}$ of a mile in length, but from always remaining full is probably as deep as the channel of the Daga river itself. It is economically valuable as a fish preserve, and an account of the annual drawing of the lake is given by the late M. O'Riley in the Journal of the Asiatic Society, Bengal. M. O'Riley speculates on the mode in which it has been formed, but as he refers it to some vague intestine movement of the neighbouring strata, I am unable to agree with his conclusions. Did such a piece of

water occur in proximity to a large river channel in lower Bengal, it would at once, and probably correctly, be referred to a deserted bend or knuckle of the river, and such was my impression in the present case before examining the ground. I anticipated finding a considerable area of newer deposit of river silt marking the former extension of the Daga river, but nothing of the sort exists, the permanent banks of the river displaying the ordinary section of older clay, and the island occupying the centre of the lake being formed of the older clay likewise. No other conclusion therefore remains but to regard it as an annular depression which originally existed on the surface of the older alluvium on its first elevation from the sea, deepened, enlarged, and wrought to its present shape by atmospheric agency. Besides atmospheric agency, which seems scarcely equal of itself to produce such a piece of water (else would they be more common), even when aided by the original contour of the ground, I should suspect some peculiarity in the soil constituting the bed of the lake. The older clay of the delta is, it is true, remarkably homogeneous as a whole, but this is not inconsistent with the occurrence in it of thin bands of a different composition. An instance in point occurs to me in the Purneah district of Bengal, where a thin band-like portion of the older clay usually so tenacious assumes almost the character of a quicksand by mixture with water, forming a sludgy compound, easily removable by the action of either springs or a stream. Some such band may very possibly occur in the older clay of Pegu, and if it occurred at about the mean height of the water on the Daga river, or lower, it would go far to explain, by the facility with which it would pulp down and flow away, the annular shape of the lake, which of course, however obscure the cause, is not purely fortuitous. In this view the original depression of the ground may have been trifling, sufficient perhaps only to give direction to the scouring action subsequently set up.*

A noteworthy point connected with the physical character of the delta of the Irawadi is the more persistent character of the river channels in it. Towards the upper part of the delta and above its proper limits, the Irawadi channel is never more than five miles broad between its *permanent banks* as they may be termed, that is the opposite margins of that trough scooped by the river in the older alluvium, and of which a considerable portion is usually refilled with river deposits. Within the delta proper towards its mouth, the present river channels are more permanent, and evince little tendency to deviate from their established channel. Even such rivers as the Daga, which wind in the most circuitous fashion in a level country, exhibit no such tendency, affording in this respect a striking contrast to the habit of rivers in the Gangetic delta. The Kosi for example oscillates from east to west (its present direction) over an area of probably not less than 30 miles, and a town which stood on the west bank of its main channel at the period of my visiting it first, stood on its east bank the following year, through the re-opening and scouring out of a disused channel in its westerly course. The station of Rampore Beauleah is in like manner suffering from the encroachment of the river, and so long back as 1855, steamers anchored where houses once stood. Nothing too is a commoner process in the Gangetic delta than the obliteration of a river channel, and its conversion into a fertile plain, a change not unfrequently effected in the course of a few years. Now, save within the narrowest limits, nothing of this sort takes place in the Irawadi delta, and this is I think attributable to the different constitution of its delta, and the absence of any extended development of the newer group, within which the incessant changes in the Gangetic rivers take place, or in other words owing to the greater and more equable resistance to erosion of an homogeneous clay like the older deposit, than what is afforded by banks composed of newer silty deposits, and such fluviatile accumulations. Local peculiarities may in some spots cause a wasting of the older clay, as at the important town of Nioungdon, where a great extent of sand flats and shallows have resulted from the excessive denudation suffered by the older clay, giving rise to a sprawling channel very different from the deep permanent channel usually seen in the delta, but the cause is obviously a local one, the clay here resting on an incoherent pebbly sand, which melts away and allows the overlying bed to topple into the river, and the process which is rather exceptional in Pegu in the older group produces the same result as in Bengal, where it is an universal operation in the newer.

* Mr. O'Riley himself subsequently to the publication of the paper referred to, changed his view of the formation of this "lake"; and believed, as certainly appears the much more rational and simple mode of accounting for its formation, that it is simply an unfilled-in bend, or as Mr. Theobald says "knuckle" of the river. Everything seems to be in harmony with this view, and Dr. Day, in his recent Fishery enquiries in Burmah, was also satisfied that this was the true explanation of the facts. T. OLDHAM.

It may perhaps seem strange, that, with so eminently level and low lying a tract of country as I have described above, over which flood waters are repeatedly effused, no considerable deposit of river sediment has taken place. The objection is to some extent plausible, but I shall now hazard a few considerations which greatly diminish its force. In the first place I would beg attention to the fact previously stated by me, which lies at the root of the entire question, and that is, that the Irawadi delta is at this present time in the precise condition which the Gangetic delta presented, when, in the latitude of Calcutta, the older alluvium, now about 65 or 70 feet below the surface and considerably therefore below the sea level, was nearly the height of the present surface and beginning to receive those accretions of fluviatile and lacustrine deposits which now constitute the 70 feet of newer deposits whereon Calcutta stands, as before shown. This is precisely the condition of the Irawadi delta, and a downward movement, with a corresponding development of fluviatile beds, is all that is required to create a strict parallelism between the two deltas. For *corresponding* development I might perhaps rather say *consequent* development, as the deposition of any thickness of these fluviatile beds is proportionate to the subsidence of the area occupied by them, hence their absence in any force, over any elevated area occupied by the older group. At the same time I do not wish to be understood as denying that the flood waters which cross the country leave no deposit, but only as insisting on the superficial and I may say insignificant development of this group in Pegu, from the reasons above given. When the entire country is composed of the older clay a thickness here and there of a few feet scattered over the surface and that after a very sparing fashion, scarcely deserves comparison with the extensive and thick deposits of Gangetic alluvium. In the river banks a couple of feet at most, and this I consider an over estimate, of surface soil is seen, the entire bank being composed of the old homogeneous clay. Farther removed from the main channel the deposition of river silt is even more trifling on two accounts; firstly from the more copious deposit of silt on the river bank, through the diminished velocity of the expanding/overflowing waters, and secondly from a cause not usually sufficiently borne in mind. It may seem paradoxical, but the low level and small inclination of the ground is a serious obstacle to its becoming silted as I shall show. When a cross country "spill" takes place and flood waters charged with sediment traverse a low country, deposition of course takes place, as when the floods of the Són abandoning their proper channel pour irregularly across the plains of Behar, and in place of falling into the Ganges above Patna, effect an irregular discharge for themselves below it. Very different, however, is the case of a river running through so flat a country as the Irawadi delta, and possessing a rain-fall such as Pegu does.

The first showers of rain fill the numerous "engs" or depressions scattered over the country, and these gradually enlarging, submerge the country before the turbid floods of the river have risen to a similar height. In default of any effective drainage, the ground adjoining the rivers being higher than the flooded interior, the ordinary rain-fall of the district is usually adequate to produce this effect, but the low land skirting the hills, receives in addition considerable, though irregular supplies through streams which pouring out from the hills diffuse themselves over the country, and lose themselves in the plains. A vast quantity of sand is swept down and forms a sort of encroaching talus margining the plains, but the somewhat depurated water mixed with the pure rain water of the plains, together forms a body of water very limpid and free from sediment, though eventually often tinged with brown from decaying vegetable matter. The turbid waters of the Irawadi now rising, top their banks, but their course is soon arrested by the limpid water of the plains and may often be traced holding on their course without mingling with the other by the contrast in colour the two bodies of water present, and this balance of power of course tends powerfully to reduce the deposition of silt to a minimum over these inundated plains and restrict it to the immediate neighbourhood of the larger streams.

In appearance the older clay of the Irawadi valley much resembles the older clay of Bengal, but it differs from it in being very deficient in lime, and rarely containing, and then but sparingly, these calcareous concretions or kunkur which give a distinctive character to the deposit in Bengal. It is a very homogeneous deposit throughout, but a thin dark band in it shows that it dips seaward, or to the south, at a greater angle than the surface of the land, which proves that the process of elevation has been greater inland than towards the gulf of Martaban. This is quite in accordance with evidence of an increased elevatory movement as we proceed up the coast, northward. Towards Cape Negrais no prominent signs

of elevation present themselves, but as we approach Gwa we find gradually proofs of a somewhat recent rise of the coast, in the shape of coral banks raised above the present limits of its growth and in the presence, a few feet below the surface in the plains now removed from the shore, of shelly sand and shells of species living on the coast. Above Myanoung this dark band is cognizable high above the dry season level of the river, but within the tideway it occurs about midwater mark or lower, and is in many places dug out for pottery, being highly plastic and adapted for such purposes.

Towards the top of the tideway the older alluvium or yellowish clay rests on a pebbly sand, which is visible at Nioungdon, where it is rather better $\frac{\text{developed}}{\text{exposed}}$ than usual. This sandy bed is doubtless the homologue of those extensive beds of gravel which towards the frontier, underlie the older clay. Opposite the village of Monyo, near Nioungwaing, gold washings are carried on in the bed of the river on a shingly bank which belongs to these coarse gravels, and these gravels are probably the source of the gold which in many spots is occasionally washed for in the Irawadi, though the returns are too poor to attract continuous labor. This older clay is not confined to the valley of the Irawadi, but occurs likewise in that of the Sittang—and, which is rather difficult to account for on any other hypothesis than that which I have adopted, of its estuary origin, in the upper parts of the river valleys on the side of the Arakan Coast. In some of these valleys it is seen deeply cut through by the river channels, and very often appearing little more than a remnant of a once extended deposit. In such positions it is often masked and covered over by an enormous accumulation of rocky detritus swept down over it by rains from the adjoining precipitous hills. This is not a situation favorable to the accumulation of a homogeneous clay, through long-continued fluviatile action, but rather points to a period when its equable diffusion took place within the sea. The coarse gravels which underlie the clay towards the upper portion of the delta and towards the frontier are clearly of marine origin, as no other agency is adequate to formations of such coarse shingle as that in question. Opposite Prome this gravel rises to upwards of 60 feet above the flood level of the Irawadi and is fully 30 feet thick reposing on miocene strata. The older clay is not seen here being apparently denuded, but at Thaietmio the relation of the two beds is well seen. In the neighbourhood of Thaietmio, this gravel contains numerous well worn and rounded pieces of fossil wood, six inches in length and occasionally logs two feet and upwards in length. These logs have, of course, not travelled far, and are derived from the miocene sands containing silicified wood in the neighbourhood. Their presence, however, with other hard rocks, in well-rounded lumps is clearly indicative of their origin in situ as a marine shingle bank. Equally conclusive is the thick deposit of coarse shingle comprising well-rounded boulders, many of six and nine inches in length of the hardest schists, exposed in the river bank under the old Fort of Miade above Thaietmio on the opposite bank, and I can draw no other conclusion from these deposits, than that, anterior to the deposition of the older clay, they formed shingle banks in a shallow sea or estuary in which their hard silicious ingredients were rolled about and polished down as we find them in the gravel. Having in a previous notice described the beds whence the fossil wood has been derived I need not here allude to them, but I think I may confidently assume that marine and not atmospheric agency was the force employed in the removal (in part at least) of these fossil-wood beds, and in reducing the silicified trunks so abundantly contained in them into the innumerable smoothed blocks, boulders and pebbles of fossil wood so characteristic of the Irawadi gravels.

I will conclude my remarks on the Irawadi alluvium by pointing out the effect to man, and the extent to which his industry is affected by what might seem merely a trivial or theoretical difference between the delta of the Irawadi and Ganges. I have already shewn that within the Irawadi delta, but 200 square miles occur of the newer or Irawadi alluvium proper, but without affecting to estimate the area occupied by the corresponding Gangetic alluvium it may be taken as far more than two hundred times that amount. Now, it is on this newer alluvium that the finest indigo is grown, and indigo and $\frac{\text{silk}}{\text{mulberry}}$ may be said to be the two main staples of the zillahs in Bengal occupied by the newer deposits. Not only this, but the newer alluvium will produce any crop required of it, either rice, sugar, opium, oil seeds, &c., and hence from the occurrence of these newer deposits over so large an area in Bengal, that province has acquired the name for fertility it possesses. In the Irawadi valley, in place of this fertile deposit, we have the older alluvial clay, which,

though where it forms an undulating country, or beyond the limits of the delta, and on the upper part alike of Pegu or Bengal, is capable of producing valuable crops of various descriptions, yet where it occupies such low land as the delta, is fit to sustain nothing so well as rice crops; and hence the inability of the delta of the Irawadi to compare in richness with that of the Ganges, or to furnish in like abundance the various products, which a seemingly trivial difference in geological composition enables her more favored sister the Ganges to produce.

Rangoon, 15th June 1869.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 2.] 1870 [May.

Geology of Gwalior and vicinity, by Chas. A. Hacket, Esq., Geological Survey of India.

The following observations will be confined to the southern part of the country near to Gwalior, included in Sheet No. 1 of the Gwalior and Central India Topographical Survey, the northern part being covered by the alluvium, which I did not examine very closely.

Physical features.—The southern part of the area is traversed by six ranges of hills; three of these have an east and west and the other three a north-east and south-west direction. Of the three east and west ranges, that to the south, extending from near the town of Par on the west, to the Sindh river on the east, is between 3 and 400 feet above the level of the plain to the south and presents a steep scarp in that direction. The other two are not so high and are less continuous; the northern range, that north of Gwalior, being formed of a line of isolated hills.

The three north-east and south-west ranges are the continuation of ranges extending to the south beyond Sipri. All of them present a steep scarp to the south-east, and incline, at a small angle, in the opposite direction, roughly parallel to the dip of the rocks.

Two series.—The rocks forming the east and west line of hills belong to an entirely different series from those forming the north-east and south-west line; the former being formed of the Gwalior Series and the latter of the Upper Vindhyan.

Unconformity.—These two series are totally unconformable to each other, the former having been immensely denuded before the deposition of the latter. In fact, I shall show presently that the principal physical features of the Gwalior series, *viz.*, the Par scarp and the two valleys included between the three ranges of hills, were in existence previously to the deposition of the Upper Vindhyan series.

Crystalline.—The narrow strip of country south of the Par scarp is occupied by the crystalline rocks. But except on the scarp and a few hillocks in front of it, the rocks are mostly covered by the alluvium. This area is also traversed by numerous large quartz veins; some of these extend for many miles in length, and attain to a height of 2 or 300 feet above the plain. Further south, these quartz veins are more numerous, longer and sometimes upwards of 500 feet high.

Crystalline Rocks.

Par scarp.—As only a small area of these rocks is exposed within our limits, my observations upon them will be very brief. The greater part of the Par scarp is formed of gneiss. Where highest there is only a capping of a few feet of the Par quartzite, the lowest member of the Gwalior series; but in most of the deep bays, which have been worn out of the scarp, and east of Deogurh where the scarp is cut back by the Sindh river, no gneiss is seen, but the quartzite extends down to the level of the plain.

The gneiss in the scarp is in a very decomposed state, and a good deal covered by the debris of the quartzites, &c. The foliation is obscure, but in places it can be traced; the strike appeared to be east-20°-north.

The gneiss most often seen in the scarp is composed of red felspar, quartz, and black mica; frequently the mica is entirely absent, and sometimes steatite is very abundant.

Another variety of the gneiss occurs at the base of the scarp, at the western end, from Deogurh to Ladera, and also in the hillocks near the latter place. The differences between the two varieties are strongly marked; this second variety is far less decomposed than the former; the hillocks by Ladera are formed of large blocks of it, some as much as 20 feet across. Foliation cannot be traced, and the felspar in it is white. Many sections of the junction between the two varieties are exposed in the scarp, in all of which the boundary between the two is well defined, the particular characters of each being as strongly marked at the junction as at some distance from it.

Quartz veins.—The strike of most of the quartz veins which traverse the gneiss is north 30° to 40° east, but I have met with one or two with a strike of north 10° to 20° west. These veins often run into the Par scarp at a height equal to the height of the scarp. Near the town of Par one of these veins can be traced for some distance through the quartzite; on either side of the vein the quartzite contains the debris of the quartz vein.

THE GWALIOR SERIES.

This series of rocks, named after the city of Gwalior, which is built on it, occupies but a small area in this district; the greatest length along the strike of the rocks being about 50 miles and breadth about 15 miles.

The series is composed of a variety of rocks consisting of quartzite, sandstone, limestone, jasper, and contemporaneous trap. The strike of the rocks is east and west, and the dip towards the north seldom at a higher angle than 3°.

I shall divide the series into two groups, viz.,—

THE PAR GROUP AND THE MORAR GROUP.

The first, the lower in the series, consists principally of a quartzite sandstone and some shales; the second includes by far the greater thickness of rocks; but in this group, there is no bed sufficiently strongly marked or continuous along the strike to be used for the purpose of sub-dividing the group.

Par quartzite.—The Par quartzite rests directly on the gneiss; and occupies the top of the escarpment extending from a little west of Par east to the Sindh river.

That the quartzite was deposited upon a very irregularly denuded surface of the gneiss can be seen where the quartz veins penetrate the scarp, as at Goojurra. The gneiss on either side of the vein had been denuded considerably below the general level, and on the east side to a lower level than on the west.

In the scarp behind Par one of these quartz veins can be traced nearly a mile through the quartzite. The vein south of the scarp runs about north-20°-east, and at the top along this line the vein is sometimes seen in the quartzite and at others is covered by it. For several yards, on either side of this line, the quartzite encloses large pebbles of quartz evidently derived from this vein.

A few inches of the base of the quartzite is conglomeritic, being formed of rolled pebbles about the size of a pea, enclosed in a matrix of red decomposed felspar; above this it becomes very fine in texture, of a greyish color and regularly and thinly bedded.

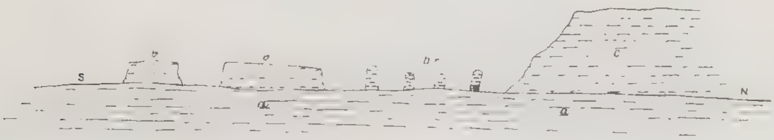
Thickness.—The thickness of the Par quartzite varies considerably. In some places, as on the top of the scarp behind Par, there are only a few feet of it between the gneiss and the Morar group, but whenever a section of the quartzite is exposed some distance north of the scarp, a far greater thickness is seen. In the Badhano gorge, situated between three and four miles north from the edge of the scarp, there is nearly 150 feet of the quartzites exposed.

Shales.—At the east end, about a mile north of the main scarp, there is a second scarp, about 100 feet high, formed of about 40 feet of green and red earthy, slightly micaceous shales at base, capped by about 60 feet of quartzite. These shales do not appear to the west, but are overlapped by the quartzites in that direction.

At the top of this group there is locally a very peculiar rock. Its greatest thickness is not more than six feet. It is best seen near Bara. East of this it is occasionally met

with, but to the west it is not seen in situ. This peculiar bed is very irregularly denuded Just south of Bara Castle channels are cut through it to the depth of the bed, leaving the rock standing in columns some feet square, and large and irregular patches of it extend for nearly a mile towards the south.

The following is a sketch section of this peculiar bed :—



a—Par quartzite; *bb*× —Peculiar bed; *c*—Shales, &c., of Morar group.

The bed presents some variety. At the point *b*,× it is composed of alternations of limestone and silicious bands; the former being softer are more worn, leaving the latter in projecting bands round the columns. The silicious bands weather into a very uneven honeycombed surface. Dr. Stoliczka informs me that they are formed of corals. In the outlying patches south of Bara *bb*, the limestone is entirely absent, and the bed is composed of a compact quartzite, often of a peculiar oolitic structure.

Small patches of this bed are seen resting on the Par quartzite eastwards almost as far as the Sindh river, but the bed is thin, and the limestone absent.

Morar Group.

The rocks of this group consist of argillaceous shales, finely laminated ribboned jasper and hornstone beds, frequently exceedingly ferruginous, but in places the iron is entirely absent. There is also some thickness of limestone having the same ribboned structure, the bands of limestone from ½ to 2 and 3 inches thick alternating with silicious bands varying from a line to an inch in thickness. The silicious bands are often of red jasper.

Trap.—The group includes several spreads of contemporaneous trap, one of them of great thickness and extent.

Thickness.—It is difficult to estimate accurately the thickness of this group, as in parts of the section the beds have a slight roll, but I should say that it must be at least 2,000 feet thick.

The line of junction between the rocks of this and the *Par group* is marked by a slight rise in the ground, seldom more than 30 feet above the top of the Par quartzite.

It is an irregular line, roughly parallel to the Par scarp. At the west end it is only a few yards north of the scarp; but eastwards the distance gradually increases, until opposite Deogurh, there is a distance of nearly five miles between the two.

Badhano.—The only actual junction between the two groups seen along the line is at Badhano. Here resting immediately on the Par quartzite are about 30 feet of white, reddish, and light green micaceous shales.

It is doubtful if these shales exist along the whole line; at all events, there can be only a few feet of them in places; they appear to be overlapped to the south, as the further north the section is situated, the greater the thickness of the shales exposed. Thus, a well situate by the side of the Bombay road, just on the top of the Ghat and about two miles north of the Par scarp, is sunk through the jasper beds nearly on to the top of the Par quartzite. In the bottom of the well, several feet of black carbonaceous shales are exposed, but in a gorge extending north from Simiria into the Par scarp to within a mile of the well, although no actual junction sections are exposed, still there is only a foot or two of the section just above the quartzite covered. No black shales are seen in this section, they may occupy the foot or two covered, but even then, there must be a great reduction in the thickness of the shales between the well and the head of the Simiria gorge less than a mile to the south

Clay beds.—At Dharoli, the beds resting upon the Par quartzite are white clays with bands of various colours. In this section not only are the black shales overlapped, but some other shales above them: thus in the Sindh river at Bijura the following section is exposed, none of which is represented in the Dharoli section.

Bijura.—The Par quartzite is not seen at base—

30 feet	black carbonaceous, slightly micaceous, finely laminated, shales.
2 ,,	ditto ditto with silicious concretions.
0 ,, 6 inches	red and green shales.
2 ,, 0 ,,	ferruginous shales with concretions.
1 ,, 6 ,,	red and green shales.
1 ,, 3 ,,	shales with silicious concretions.
2 ,, 0 ,,	red finely laminated ribboned shales.
4 ,, 0 ,,	ditto with silicious concretions.

Concretions.—The concretions occur as flattish round balls of flinty chert, sometimes 1½ inches in the shorter, and 2½ inches in the longer diameter; the longer diameter always being parallel to the bedding.

In the Dharoli section the clay beds pass upwards into an irregularly banded rock; the bands of from one-eighth to one-half an inch in thickness and formed of alternate bands of hornstone and silicious brown hæmatite, the bands of hornstone being most frequently the thicker of the two. The clay beds appear to be very local in their occurrence; for in many places, the hornstone beds form the bottom of this group. It seems possible that the clay beds are the hornstone beds locally decomposed. The two are very similar in structure; the hornstone is seen in all stages of decomposition, and the rocks somewhat higher in the section, and equally silicious with the hornstones have certainly decomposed into a similar clay, as, for instance, at the iron mines near Mangor and Santow, &c., where the red and yellow clays can be traced along the strike into the undecomposed red and yellow jaspers.

The thickness of the clay and hornstone beds is about 50 feet. The section above them in ascending order is as follows:—

	Feet.
Red ribboned jasper with ferruginous bands	150
Ribboned hornstone	50
Red and yellowish, slightly ferruginous, finely laminated, banded shales ...	50
Silicious ribboned shales	40
Felsites and shales	20
Contemporaneous trap (Choura trap)	70
Felsites and shales	40
Limestone with bands of chert	50
Felsites and shales	60
Contemporaneous trap (Bela trap)...	50
Silicious finely laminated ribboned shales, including bands of limestone ...	300
Ribboned jasper and ferruginous shales	300
Contemporaneous trap (Morar trap)	500
Ribboned jasper and ferruginous shales	50
Limestone with bands of chert and jasper	70
Ribboned jasper, with ferruginous bands	50
Semi-jaspideous ribboned shales	100

Concretions.—Concretionary structure is very common in the lower part of this section, particularly in the jasper-beds. Some of the concretions in these beds are four feet long and four inches thick, but the greater number are about six inches long and 1½ inches thick; the longer axis always parallel to the bedding. The concretions are formed of thin laminæ of red jasper and hæmatite, and are mostly irregularly cracked in the interior and the cracks filled up with quartz crystals. In some of the concretions there are irregular cavities, sometimes 4 inches long and 2½ inches high, lined with quartz crystals. The best sections of these beds can be seen in the gorges north of Simiria, where vertical cliffs of them more than 100 feet high are exposed. The beds of this part of the section are locally worked for iron. A description of the mines will be given presently.

Felsites.—The felsites occur above and below the Choura, Bela, and Puniar traps, as well as under the outlying hillock of trap near Fasoulee. They are mostly thin and regularly bedded, and in this respect resemble the silicious shales, with which they alternate.

The most common variety of the felsites is a cream coloured felspathic matrix, in which are imbedded innumerable dark coloured crystals, probably of augite. Another variety consists of alternate irregular, thin light-cream, and dark-green, coloured layers, probably of felspar and hornblende.

The following is an analysis of one of the felsites by Mr. Tween :—

Silica	60·50
Alumina with a little iron	24·51
Lime	2·08
Magnesia	1·32
Potash	9·16
Soda	4·51
Total	102·08

Mr. Medlicott, who has examined a portion of this area, found in the nuddy south of Raipoor some spherical hollow lumps imbedded in the felsites, which he describes as "volcanic (?) bombs, spherical hollow lumps of coarse trappean matter, imbedded numerously like great drops in one of the fine compact intertrappean beds a few feet over the Choura trap flow in section south of Raipoor."

It is difficult to arrive at any conclusion as to the origin of these beds; but from their association with the traps, their general appearance, and composition, it seems probable that they are trappean ash-beds.

Limestone.—The limestones are very uncertain in the section. Of the two limestones exposed in the Dharoli section, the lower, that between the Choura and Bela traps, is covered by the alluvium both in the east and west of the line of section. The upper is very discontinuous along the strike; at some places there is a considerable thickness of it, while in others it is entirely absent.

Uncertain occurrence of limestone.—The best instances of the uncertain occurrence of the limestone are at Bhandaoli, Siharo, and Dangora.

At Bhandaoli the hill is about 150 feet high, in which, in ascending order, the following section is exposed:—

	Feet.
Silicious shales	15
Calcareous shales with bands of limestone	20
Limestone	100
Silicious jasper-shales	20

The beds are nearly horizontal; only a few hundred yards further to the east there is no limestone in the section. On the west side, under the castle, the limestone is replaced by ochreous clay beds, in which are a few thin bands of limestone. A short distance further west, the only limestone in the section is in the calcareous shales at the base of the hill.

Siharo.—About a mile east of Siharo and north of Ootilla there is a hill of limestone nearly detached from the main range. The hill is about 100 feet high. On the south side, on the top, there are about 70 feet of limestone; under this about 20 or 30 feet of calcareous shales with bands of limestone and at base silicious shales. In the main range not 50 yards distant there is not a trace of limestone.

Dangora.—Another instance of the uncertain occurrence of the limestone is at Dangora. Here there are about 50 feet of limestone seen in section. It continues round the north side of the hill, but at a short distance to north-east the limestone becomes more earthy until it passes into the ochreous clays. East of Dangora, the limestone continues for a short distance towards Fasoulee, but at that place none is seen in the section.

I might mention many other cases of the sudden disappearance of the limestone, but I think the above sufficient. The rock that replaces the limestone in the section is always the ochreous clay beds. The limestone and the accompanying rocks are as nearly as possible horizontal, so that the sudden disappearance of the former cannot be accounted for by dip. The beds above and below the limestone being identical with those above and below the ochreous clay beds prove that the limestones are not faulted out of sight.

TRAP.

There are at least four separate spreads of trap. I shall name these the "Morar trap," the "Barai trap," the "Choura," and the "Bela trap;" there is also a large spread of trap west of Puniar; this, I think, is a disconnected part of the Barai trap.

Besides these great spreads, several smaller patches occur, as at Kote ki Serai, Malipoora, Singpoora, Baroori, and Fasoulee. It is probable that some, if not all,

of these patches are parts of the four great spreads, although the connection cannot be traced, as these parts of the section are a good deal covered by the alluvium.

Morar trap.—The Morar trap is by far the most important from its greater thickness and extension along the strike. A map would scarcely convey a correct idea of its great extent and thickness; as to the eastwards the trap is only seen at the base of the broken northern range and in the isolated hills dotting the Morar plain; but there can be no doubt, these isolated patches, and the trap under the hills round Gwalior, form part of one great spread, extending from Bitholi on the west to Jhankri on the east, a distance of about 30 miles. The western end of the Morar trap is covered by the Kymore sandstone, and the eastern by the alluvium. There does not appear to be any thinning out at either end, for at Bitholi and Jhankri there is as great a thickness as anywhere along the line. About four miles west of Bitholi, in a gorge near Malipoora, the Kymore sandstone is removed and a considerable thickness of trap is exposed. This is just in the line of the strike of the Morar trap and most probably is a continuation of it.

Thickness.—The thickness of this trap must be considerable, although it is difficult to estimate it accurately. The breadth of the spread, at right angles to the strike, is at the western end upwards of three miles. The rocks immediately above and below the trap dip at an angle of 2°, and if the trap has the same dip, it must be upwards of 500 feet thick. But as there may be an alteration in dip between the northern and southern edges, this estimate is possibly excessive. At all events, there are vertical sections exposed in Gwalior fort hill, and some of the hills to the west, showing nearly 200 feet of trap, and some of the hills on the Morar plain, as at Dhaneli, Atarsoo, and Karwas, are nearly 100 feet high and are formed entirely of trap.

Barai trap.—The Barai trap occurs on the south side of Barai hill. It extends to the east nearly as far as Tigara, where it is covered by the alluvium, and on the west for a mile, and is then covered by the Kymore sandstone. There is about 50 feet of this trap exposed in the Barai hill. The small patches of trap, which crop out from under the Kymore sandstone, south-west of Bara'i, are obviously parts of this spread. The reason of its occurring in detached patches is, that the trap was largely denuded before the deposition of the Vindhyans, and that now, the Kymore sandstone rests sometimes on the trap and at others on the rocks below.

Puniar.—The trap at Puniar is about 1½ miles south of the southern edge of the Barai trap, and of which, although the continuation cannot now be traced, it probably once formed a part. The traps are of about an equal thickness, and the beds above and below them are very similar.

Choura trap.—The Choura trap is about 70 feet thick, and extends continuously from Naigaon, just east of the trunk road, to Choura. East of this, it is covered by the alluvium, but its continuation can be traced some distance further east, as small hillocks of trap are of frequent occurrence in that direction. It is probable that the trap seen in the stream north of Barori is a continuation of this spread, as the limestone on the top of it is very similar to that over the Choura trap.

Its continuation westwards can also be traced, for in the nuddy south of Raipoor, about two miles west of Naigaon, a small patch of trap is exposed, which is probably a part of this spread.

Bela Trap.—The Bela trap is about 150 feet higher in the section than the Choura. It is covered by the alluvium at both the east and west ends, but to the eastwards, there are many outcrops of trap along this line, the farthest of which is at Kote ki Serai, about six miles distant; these all doubtless belong to this spread.

At the northern end of this spread, in the nuddy near the trunk road, north-west of Bela, the trap has the appearance of having broken through the strata and overflowed the rocks to the south. For a distance of about 20 yards, the nearly horizontal shales, upon which, immediately to the south, the trap rests, are seen in actual contact with the vertical trap for a depth of about six feet. East of this section the trap is covered by the alluvium, but to the west it is regularly interbedded with the shales.

Raipoor.—In the nuddy near Raipoor a similar apparent case of intrusion is seen, but here unconnected with any overflowing trap.

The variety of trap forming the different spreads is diorite. It is mostly largely crystalline, the separate crystals of hornblende and felspar being visible to the naked eye. On the top of the Morar trap near Beipoor magnetic iron is very abundant in the trap, but with this exception there is little variety in the trap of the different spreads.

THE VINDHYAN SERIES.

Already described.—The western part of our area is occupied by the rocks of the Upper Vindhyan series. This formation, including that portion of it here represented, has already been reported upon by Mr. Mallet, (Mem. Geol. Surv., India, Vol. VII., Pt. 1).

Relation to Gwalior.—I shall therefore confine my remarks to its relation to the Gwalior, and, principally, to showing the extensive denudation of the latter previously to the deposition of the former. Only the two lower groups of the Upper Vindhyans, *viz.*, the *Kymore* and *Rewah*, are here represented; they form three parallel ranges, extending from the south in a north and south direction, but north of the Par scarp they trend to the north-east. The most easterly range is formed of the Kymore conglomerate and sandstone; the next–a few miles to the west–of the shales and sandstone of the Lower Rewahs, and the third–still farther west–of the shales and sandstone of the Upper Rewahs.

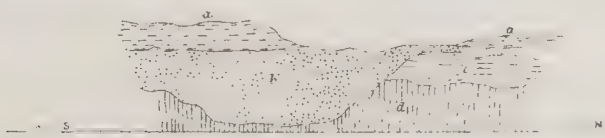
Outliers.—There are also many outliers of the Kymore group resting upon the Gwaliors; one of the largest of these is the Gwalior fort hill, the upper half of which is formed of the Kymore rocks.

Unconformity.—The Kymore cross the whole of the Gwalior section, and along the line of junction numerous sections of the unconformity of the two series are exposed.

Kymore conglomerate.—Further evidence of the unconformity is shown by the Kymore conglomerate, which is formed, almost entirely, where it crosses the Gwaliors, of angular and slightly rolled pebbles of red jasper obviously derived from these.

Doorsari.—But the most interesting sections of the junction of the two series occur in the two gorges near Doorsari at Ladera and near Bhastori. These sections not only show the extensive denudation of the Gwaliors, but also that their present physical features, as, for instance, the Par scarp and the two parallel valleys, existed before the deposition of the Vindhyans.

The Doorsari gorge is situated at the western end of the Par scarp about a mile beyond the western limits of the map. South of the Par scarp the Kymores rest directly on the gneiss and form a scarp running nearly north and south. The section is at the point of contact with the north and south scarp and the Par east and west scarp. The two scarps are each about 200 feet high. The Par scarp is formed of about 150 feet of gneiss capped by 50 feet of Par quartzite. The Kymore scarp a few hundred yards from the contact has about the same thickness of gneiss at base, but capped by the Kymore conglomerate and sandstone. At this point, the conglomerate is only a few feet thick; north of this, the top of the gneiss falls rapidly to nearly the level of the plain, and its place in the scarp is filled by the Kymore conglomerate. At the point of contact of the two scarps, there cannot be less than a hundred feet of the conglomerate resting against the steep Par scarp. At the top of the Par scarp, the conglomerate is only represented by a few pebbles, but it gradually thickens on the low ground to the north.



Junction of the Vindhyan and Par scarps near Doorsari: *a*—Kymore sandstone; *b*—Kymore conglomerate. *c*—Par sandstone; *d*—Gneiss

The second gorge occurs a short distance east of the above. On the west side, a similar section to that just described is exposed. The gneiss falls to nearly the level of the plain, and the Kymore conglomerate increases proportionally in thickness, until, immediately south of the Par scarp, it is nearly a hundred feet thick.

In fact, the ground between the gorges, nearly half a mile, is occupied by a large outlier of the Kymores, at the southern end of which (about a mile from the Par scarp), the conglomerate is only a foot or so thick, but at the northern, there is a hundred feet of it abutting at base against the steep cliff of gneiss, and at the top against the edges of the horizontal Par quartzite, which at the top of the scarp it covers.

Ladera.—The next case proving the existence of the Par scarp previous to the Vindhyan epoch is near Ladera. It is situated just south of the Par scarp, about 24 miles west of the Doorsari gorge. Here the Kymores are seen at the level of the plain, and abutting against the scarp of gneiss and Par quartzite. It is also seen on the top of the scarp. The gorge in the scarp, just west of the narrow spit of sandstone, is also partially filled up with the Kymore sandstone. The bottom and west side of the gorge are of nearly horizontal Par quartzite, but the east side is formed of the Kymore sandstone.

Western extension of Par scarp.—There is also some evidence that the Par scarp extended west of the Doorsari gorge, for at Sirsa, about three miles west, there is an outcrop of the Par quartzite, and the Kymore sandstone is seen at a lower level immediately to the south of it.

Outlier of Vindhyans at Bastari.—At Bastari there is a large outlier of the Kymores, stretching nearly across the southern valley. The hill is upwards of 100 feet high, composed of massive irregularly bedded horizontal sandstone. The base of the hill is covered by debris, so that the Kymore conglomerate is not exposed. Patches of the sandstone rest, unconformably, on the ridges of the Gwaliors, both north and south of the valley. On the south side many of the steep lateral gorges running into the main valley are partially filled up with the Kymore sandstone and conglomerate. It is obvious that the southern valley and the lateral gorges must have been worn out before the Vindhyan epoch, as no amount of faulting could have brought the sandstone into these gorges.

Section near Bastari: *a*—Kymore sandstone; *b*—Jasper beds of the Gwalior series; *c*—Par sandstone.

Small outliers.—There are many other smaller outliers of the Kymore, particularly near Jarga and Sohnsa. They mostly occupy the low ground, partially filling up gorges, or resting upon the sides of the hills of the Gwaliors, in all cases showing the extensive denudation of the latter previous to the deposition of the Kymores.

The question of the age of the Vindhyan series has already been discussed by Mr. Mallet in his report (Mem. Geol. Surv., India, Vol. VII, Pt. 1).

Gwaliors.—The unconformity of the Gwalior series in our area to the gneiss on which they rest, as well as to the covering Vindhyans, is so great, that no conclusion can be drawn as to the exact place of the Gwalior series in the Indian series.

Hindown.—The only other place where the Gwalior series has been identified to a certainty is near Hindown, about 60 miles north-west of Gwalior. The Gwaliors there form a ridge about ten miles long, extending in a south-west and north-east direction. The beds are thrown up at a high angle, seldom dipping less than 60° in a north-westerly direction. Only a few hundred feet of section is exposed. The ridge is entirely surrounded by the alluvium, and thus isolated from the other rocks of the neighbourhood.

Upper Vindhyans.—The rocks nearest to the Gwalior ridge are the Upper Vindhyans, the upper group of which, the Bundairs, form a high scarp running nearly parallel to the ridge. The Bundairs are for the most part nearly horizontal, but sometimes at their north-western limit dip at a high angle towards the south-east. There are two other broken ridges in front, north-west of the Bundair scarp, dipping at a high angle to the south-east, probably formed of the lower groups of the Upper Vindhyans, *viz.*, the Rewah and Kymore. The nature of the junction between the Vindhyans and the Gwaliors is obscured by the alluvium.

Byana hills.—A few miles north-west of the Gwalior ridge, and roughly parallel to it, is another line of hills extending from Byana in a south-westerly direction.

Quartzite series.—These hills are formed of a series of rocks not yet described, which we have provisionally called the 'quartzite series.' It consists of an immense thickness of quartzite sandstone, shales and conglomerate. The lowest group includes numerous spreads of contemporaneous trap.

The quartzite series is most probably more recent than the Gwalior and older than the Vindhyan, for the conglomerate of the middle group (Dumduma) of the quartzite series contains pebbles of ribboned jasper, &c., almost certainly derived from the Gwalior series; and some distance south-west of Hindown, near Kerowlie, the Upper Vindhyans rest unconformably upon the lowest group of the quartzite series.

Lower Vindhyans.—Lithologically, the Lower Vindhyans of Bundlekund have some resemblance to the Gwaliors, particularly to the silicious shales of the middle range of our area, but the ribboned jaspers, so characteristic of the Gwalior series, are entirely absent.

It is highly improbable that the Lower Vindhyans and the Gwaliors are synchronous deposits, for no unconformity beyond overlap has been detected between the Upper and Lower Vindhyans in Bundlekund, and yet the lowest member of the Upper Vindhyans, the Kymore conglomerate, is composed largely of pebbles of red jasper, almost certainly derived from the Gwalior series. Again, in the Sone valley, a considerable thickness of ribboned jasper occurs, identical in appearance with the jasper of the Gwaliors, and which series it probably there represents. The Lower Vindhyans rest unconformably upon these jasper beds.

Bijawars.—The Bijawar series and the Gwalior have many points in common; but still the characteristic jasper beds of the latter are not represented in the former. The relation of these two series to each other has therefore yet to be determined.

LATERITE.

There are two patches of laterite in our area; one at Raipoor hill, of which it forms the peak, the highest ground of the district; the second occurs on the Kymore sandstone, about two miles to the north-west. Both these patches are small in extent and are about 60 feet in thickness. The beds composing these hills are exactly similar to each other, and to the great spread of laterite of Central India—purple clay with bands of brown hæmatite at base, capped by the hard porous rock-laterite,—and no doubt, these two hills are outliers of the Central India spread, which has been traced as far as Sipri, about 60 miles south of the Raipoor hill.

ECONOMIC GEOLOGY.

Upper Vindhyans.—Mr. Mallet has already described the resources of the Vindhyans in his report on them; in this district the sandstone, both of the Kymore and Lower Rewah, is largely quarried for building stone. The new barracks on the top of the Gwalior Fort hill are built of the Kymore sandstone, quarried from the top of the hill.

Iron.—The principal production of the Gwalior series is iron. Formerly, the workings for iron were far more extensive than now, judging from the large excavations to be met with. The peak of Par hill is completely burrowed by the old workings and a large portion of the hill removed. Similar extensive excavations occur at Mangor and other places. The reason that the workings are not so extensive now as formerly is, not that the iron is exhausted, but that the wood to smelt it is used up; all the hills for many miles round Gwalior being almost entirely bare of any tree or jungle, the ore has now to be taken a long distance to the furnaces.

Par Hill.—The principal iron mines are situated at Par hill, Mangor, and Santow. Nearly all the workings are confined to the lower part of the Morar group, about 100 feet above the Par quartzite. That on Par hill, not now worked, occurs in an outlier of the Morar group, forming a peak rising to the height of about 60 feet above the level of the edge of the scarp. The lower part of the peak is composed of white clay beds with very regular variously coloured bands. The beds of the upper part of the peak are highly ferruginous, the iron occurring in thin laminæ in the variegated clays. It is from these beds that the iron is extracted.

Mangor.—The Mangor mines, about three miles north-north-east of Par hill. These workings are confined to a narrow valley running north and south and nearly half a mile long. On the east side they are bounded by a vertical cliff, the workings extend some 200 yards west of this, but the greater part are close under, or only a few feet west of the cliff. The richest seams are worked by small shafts some 30 or 40 feet deep; but on the west side of the valley iron is quarried from the sides of the low hills. The section in the shafts is very similar to that on Par hill, and the iron occurs in similar fine laminæ in the clays.

In the quarries, on the high ground, on the west side of the valley, the iron is extracted from beds above those on Par hill. These beds, although greatly decomposed, resemble the lower beds of the Morar group; the structure is the same, and they enclose concretions similar to those which occur in the Morar group; but here the jasper and flint, &c., forming the concretions are decomposed into red and white ochreous clays. Both east and west of this valley, the clay beds pass into the undecomposed beds of the Morar group.

Santow.—The workings at Santow are also confined to a narrow space. They are bounded on the north by a large quartz vein, and the principal workings are close to this. The richest beds are reached by small shafts about 50 to 60 feet deep, from which small galleries are extended.

The beds from which the iron is extracted are the same as those worked at Mangor and Par; they are in a similar decomposed state, and pass both to the east and west into the jasper and hornstones of the series.

Smaller mines.—Between Mangor and Santow, on the high ground, there are several workings, but most of them small; there is one place, however, near the curious old tree marked on map, where extensive excavations have been made.

All these workings are on the same horizon as those of Par, Mangor, &c., and the iron is extracted from similar clay beds, which pass into the undecomposed jasper and hornstone rocks in all directions.

The strata in all these mines are locally much contorted. In places there are vertical narrow strips of the undecomposed rocks, running through the clay beds in all directions. These strips are generally from three to six feet wide, and stand up like a wall, sometimes ten feet high. They are mostly formed of thin laminæ of iron, and show sharp contortions, even in their small breadth. They are even harder and more silicious than the unaltered rocks on this horizon, as if the silica from the decomposed beds through which they pass had been secreted in these strips. Iron is not more abundant in the parts worked than in a great part of the series, both on the same horizon and in other parts of the section.

The laminæ of iron are as thick and numerous in the hornstone and jasper beds as in the clay beds derived from them. Again, in the very highest part of the section, above the Morar trap near Kharia, the iron is quite as, if not more, abundant. The reason, that the places worked were selected, was on account of the local decomposition and softening of the rocks containing the iron.

The miners told me that they sold the ore at the pit's mouth at the rate of between 60 and 70 maunds for the rupee.

Limestone.—The limestone is quarried and burned, but not on an extensive scale, as the natives appear to prefer the kunkur to be found in the alluvium just west of Gwalior.

Black shales.—Some small excavations were made in the black shales in the bottom of the well by the side of the trunk road west of Puniar, in the hopes of their leading to coal, but, of course, without success; the shales containing only a trace of carbonaceous matter.

NOTE ON THE SLATES AT CHITÉLÍ, KUMAON, by THEO. W. H. HUGHES, F. G. S., Geological Survey of India.

Whilst at the hill sanatorium of Almora during the late recess season, I was requested, in a letter addressed to me in September last by Colonel Hodgson, R. E., the Secretary to Government, North-Western Provinces, Public Works Department, to express an opinion, after visiting the spot, as to the suitability of some slate for roofing purposes, which was known to occur near a village called Chitélí, distant only a few miles from Dwara Hát, one of the well known camping localities between Nainí Tál and Masúri.

Slate required for roofing.—The question to decide was one of importance, for, if the slate were pronounced suitable, it was intended to use it extensively for roofing the military buildings that were to be constructed at the new station of Raníkhét; it having been estimated by Captain Birney, R. E., the Executive Engineer in charge of Raníkhét, that after taking into consideration the cost of extraction and carriage, the employment of slate would be much cheaper than the corrugated iron in general use for roofing at most of the hill stations.

The following short paper sets forth the views which I entertain regarding both the quality of the slate and the quantity of it available. It would have been impossible, however, for me to have arrived at a satisfactory and reliable conclusion on the first of these points had I not received considerable and courteous assistance from Captain Birney.

Colonel Hodgson's letter reached me on the 17th September, but I did not proceed to Chitélí until the 9th October owing to the lateness of the rains and the reported unhealthiness of the spot.

Position.—The slate occurs in a spur of the hills overlooking a gorge, near the mouth of which the village of Chitélí is built.

In this spur an experimental quarry was opened out, but when I visited it, although efforts had been made to clear away the debris that obscured the section, the extraordinary continuance of the rains prevented the men at the quarry from working as rapidly as they otherwise would have done; and not more than 30 to 40 feet of rocks below the surface were exposed.

The slates dip at high angles; and, as may be presumed, there are different bands varying in their comparative goodness. None of the slates are cleaved in a definite manner, but a few do exhibit this structure in an incipient stage.

Before proceeding to purely economic matters, it may be useful to give, for the information of those who take some interest in geology, a generalised section of the Himalayas, in order to show roughly the horizon which the slate-rocks of Chitélí occupy.

Geological Section.—Commencing at Kálídúngí at the base of the hills, and carrying the section beyond the British frontier through the Milam pass, the rocks occur in the following order of succession:—

A.—Sedimentary rocks. Principally sandstones, shales, and limestones. A few carbonaceous beds occur. Seen on the road from Kálídúngí to Nainí Tál.

B.—Metamorphic rocks. Schists, quartzites; different varieties of gneiss; slates and greenstones. Seen at Nainí Tál, and from thence to Múnshiárí.

C.—Gneiss, with numerous granite veins. Seen between Múnshiárí and the upper Botíá villages of Búrfú and Milam.

D.—Sedimentary rocks,* corresponding to the older, secondary, and newer rocks of European classification. Seen between Milam and the Sutlej river.

The Chitélí slate forms a horizon in the class of rocks under the heading B,—the same class in which the greater portion of the mineral wealth of the Himalayas is contained.

The general quality of the Chitélí slate bears favorable comparison with other Indian specimens; but it is below the standard of typical Welsh slate.

Quality.—It differs from the latter in splitting along the planes of lamination, instead of the planes of cleavage. It is coarser in texture: more silicious (sandy), heavier, and has a duller ring on being struck. Assuming the value of typical Welsh slate as 10, the general value of the Chitélí slate would not be more than 6. There are, however,

* From this band come the *Ammonites* (Salígrám) and the *Belemnites* (Chúchí pathar), which those who cross the snows bring back with them as mementos of their travails and their travels.

some slates,—those occurring about 40 feet below the slates that crop out at the top edge of the spur above the quarry,—which are of somewhat higher value, being closer grained, possessing very even planes of lamination and splitting into thin slabs. These slates form a distinct band, their colour being darker than that of those above them.

In recommending which slates should be utilised, I would certainly say the lower ones; the upper slates being altogether coarser and containing some iron galls.

I am sorry that I possessed no means of testing the absorbing power of the specimens which I brought away with me from the quarry. But Captain Birney assures me that he has carried on experiments during the past twelve months to prove the porosity of the slate, and that the results have been satisfactory. Captain Birney, to further test the slate, had exposed several slabs to the action of the weather. All, with the exception of one which had cracked, were perfectly sound when I examined them. The cracking of one slab I look upon as a matter of little moment as affecting the quality of the slate, for all the specimens had been procured from near the surface; and I believe that this cracking will not occur when the slates are quarried from a lower depth.

Supply.—With regard to the question of supply there need be no fear. If the spur of the hill be opened out on both sides, there will be a store of slate more than ample to meet all the demands of the barracks at Raníkhét. The beds have only to be followed along their strike to yield an unlimited amount of slate.

To conclude, I consider the Chitélí slate good enough for roofing purposes. And that slabs less than $\frac{1}{4}$ of an inch in thickness and much more than a square foot, superficial measurement, may easily be obtained.

I would recommend, should the working of the quarry be determined upon, that some competent person should be appointed to pass the slates. Native labourers are too indifferent to take any interest in their work, so that no dependance can be placed upon them; and they would just as willingly waste their time in splitting bad slate as they would in splitting good. The employment of one or two skilled slab-men to supervise the other labourers and also to work, would in the end be more economical than trusting to the local abilities of the Chitélí villagers, as they would probably spoil through carelessness an endless number of slates.

NOTE ON THE LEAD VEIN NEAR CHICHOLI, RAIPÚR DISTRICT, by W. T. BLANFORD, Esq., Assoc., Roy. School of Mines, Dep. Supdt., Geological Survey of India.

The following is the result of a brief surface examination of the locality near Chicholi at which lead was discovered three or four years since by Mr. Smart of the Revenue Survey. The spot is rather more than 70 miles west of Raipúr on the road to Bhandára and Nágpúr.

The ore (galena) occurs in a well marked vein, chiefly composed of quartz, which traverses the metamorphic rocks. The latter are not well seen in the neighbourhood of the vein, but in the surrounding country consist chiefly of granite or granitoid gneiss and hornblend schist passing into diorite. Besides quartz the vein contains pink felspar in considerable quantities, green and purple fluorspar, and a green mineral, probably epidote. Galena is sparingly disseminated throughout the mass for some distance on each side of the road, and I found slight, but unmistakeable, indications of the presence of copper; small quantities of the green carbonate occurring in several places.

In some parts of the outcrop there is a large quantity of peroxide of iron, sometimes as a coating on the surface, sometimes irregularly mixed with quartz ("gossan"), and evidently resulting from the decomposition of some other mineral. This is a common occurrence at the outcrop of mineral veins, and is, I believe, usually considered a favorable indication by miners, in copper veins at least. But the value of such indications depends greatly upon local conditions. Large masses of peroxide of iron and quartz, or "gossan" as it is termed in Cornwall, are seen just north of a little peak about quarter of a mile north of the road.

The direction of the vein is N.-10°-E.—S.-10°-W.: it forms a series of ridges, some of which are at least 100 feet high above the surface of the ground. I traced the vein for about half a mile north of the high road and for at least a mile to the south.

Beyond the distance mentioned to the north, I could find no signs at the surface of its occurrence, but I did not search far. To the south it doubtless extends beyond the spot to

which I traced it, and a hill is seen in the direction in which the vein runs, which may be formed of the quartz.

The width of the vein, as usual, varies greatly. Near the high road, both north and south, it cannot be much less than 30 feet. About a quarter of a mile to the south, this thickness gradually decreases to about six feet. At this spot the veinstone rises like a wall above the surface of the little ridge formed of its quartzose debris, and the direction of its dip, obscure elsewhere, is distinctly seen. It here underlays to the eastward at an angle of about 10° from the vertical, in other words, it dips at 80°. Beyond this, to the south, the thickness probably diminishes still further, as, for about quarter of a mile, the vein can no longer be traced at the surface; beyond that distance it again forms a ridge of some height.

It is simply impossible from the surface examination of a metallic vein, especially in a district where no mines exist, to ascertain what its value may be below the surface. All metallic mines are more or less speculations. Taking into consideration the large amount of veinstone exposed, the proportion of galena seen is small, and unless the quantity of lead ore be greater below the surface, it will not alone pay for the working. It should be observed that the fresh unaltered appearance of the galena found renders it impossible that its paucity is due to the greater portion having decomposed. But larger masses may occur below, and there is also a probability of copper ore being found. The occurrence of the ores in a well marked vein is certainly a most important circumstance, and I may add that it is the first instance of a distinct metallic lode that I have seen in India.

Altogether I think it may safely be stated that there is nothing in the appearances presented by the Chicholi lode inconsistent with the occurrence of a good vein of lead and copper ore below the surface. There are two disadvantages in the locality: the absence of workmen acquainted with mining and want of water, not merely as a motive power for pumps, &c., but for stamps and washing floors. But these are only questions of expense, and should rich ores occur, will readily be overcome.

At Wúrâband, 16 miles east of the Chicholi lode, two rather irregular quartz veins occur, forming hills of considerable size. I saw no traces of ore or of fluorspar in these, but my search was necessarily hurried. The direction of these veins approximates to that of the Chicholi lode.

17*th March* 1870.

Better specimens than before accessible have been assayed, and yielded 9 oz. 19 dwts. 6 grs. of silver to the ton of lead.

The Wardha river Coal-fields, Berar and Central Provinces.

The last notice of these coal-fields was given in the Records of the Geological Survey of India, Vol. II, pt. 4, p. 94. Since that time great progress has been made in the detailed exploration of the field, and it is now possible to give a tolerably accurate estimate of the extent of area over which the coal can be traced, and of the amount which is available, in the vicinity of the river Wardha.

This river Wardha forms the boundary between the Central Provinces, lying to the east of the river, and the 'Assigned Districts' (Berar) and the Nizam's Territories, lying to the west of the river. The same boundary is continued further to the south by the Pranhita, as the stream is called after the junction of the Wardha and Weinganga, and still further to the south by the Godavery, as the continuation of the same stream is called after the junction of the Pranhita and Godavery, near Sironcha.

Previously to the recent exploration the only places where coal had been actually found, were a few points exposed by the cuttings of this river. The whole surface near the river is so covered with widely extended beds of calcareous gravels and conglomerates (? pliocene) and thick masses of sands and clays and often of regur, or black cotton soil, that, as a rule, very few, and these very limited and imperfect, sections are seen and the structure of the country must to a large extent be imagined or built up from these small sections. Although thick beds of coal were visible in the banks of the river, their continuance inland could not be traced, and even where the rocks were exposed, the denudation had been so great, and the thickness of the covering clays, &c., was so considerable, that the outcrops of beds of such marked character as coal and coaly shale of 40 and 50 feet in thickness were entirely concealed. And it therefore was essential that actual borings should be put down. The results of a few of the early trials were given in the notice referred to above. (Vol. II, p. 94).

Shortly after the publication of that notice three additional sets of boring tools were received from Europe, and were at once turned to account. And sometime later, a steam boring machine of Mather and Platt's construction was delivered at Chanda, and preparations were made for working it. I shall now give briefly the principal results obtained.

The two brace headmen who had been sent out from England had both suffered from the climate. Mr. Heppel had a very serious attack of fever, and was for a time dangerously ill. But he got over this attack, I am happy to say, and resumed his work as zealously as before. Mr. Longridge had suffered slightly at several times from the effects of the sun; and I regret to say, the attacks became more frequent and severe, until it was necessary that he should be invalided and sent home at once. The advantage of his aid was lost from the very commencement of the open season. Mr. Bateman Smythe was appointed (10th December) in lieu of Mr. Longridge, and has proved a most efficient and useful Superintendent of the Works. Mr. W. Penn Mather, who had had very considerable experience in boring with the steam boring machines constructed by the firm with which he was connected (Mather and Platt) and who had temporarily come to India, was appointed to take charge of the Steam Borer, and joined in the beginning of February.

Taking up the narrative of the exploration from the time of last report published in these Records, I will now briefly give a notice of the principal facts.

I shall not at present delay to give the full details of the sections cut through at the various holes, but simply enumerate the localities where these have been put down and state the results. The details will more appropriately be given with a more detailed geological report.

Up to November 1869, as already stated, only a few unsuccessful borings, in which nothing but thin unworkable beds of coal had been met with, had been carried out. A deeper boring to the east of Chanda town on the road to Moolh, and on the banks of the Jhurput Nuddi, was then in progress; and this was subsequently carried down to a depth of 248 feet. At this depth the progress made with the poor windlass power then at command was so slow, and the importance of determining the existence of coal elsewhere so much more pressing, that it appeared wise to stop this boring, more especially as there was nothing definite tending to show the probability of a change in the rocks within a short distance. The tools were therefore moved elsewhere. The same section is now being proved by the steam boring machine, with the additional advantage of testing the upper rocks for a considerably greater thickness. The borings to the south of the town of Chanda, although it was evident that they had been put down altogether outside the outcrop or line where the known coal, if it occur, could be traced, were not resumed, as it seemed better to reserve these for the monsoon, when men could find good shelter in adjoining bungalows at a time when it would not be possible to remain with safety in tents. A systematic examination, therefore, of the country extending northwards from the known coal locality near Ghúgús was commenced, and has since then been steadily carried out. One additional bore hole was put down between the pit sunk on the coal near Chandur on the bank of the Wardha and Nokora. This was due west of the village of Ghúgús, and was intended to supply the information which we had been prevented from obtaining in nearly the same place by the loss of the mineral lifter in the boring there. The object of this was to prove the actual amount of variation which the seams showed within this distance of three miles. This variation will be best seen in the accompanying details.

Ghúgús North.

	Feet.	Inch.
Black shale ...	2	0
Coal .	3	0
Dark sandy shale ...	3	0
Coal . .	3	0
Blue shale ..	5	6
Coal . .	12	0
Coal with iron pyrites	4	0
Coal ...	5	0
Shale	0	6
Coal	11	0
White sandstone.		

Ghúgús W. of village.

	Feet.	Inch.
White sandstone .	8	6
Coal	3	0
Shale mixed with coal	2	0
Coal	3	0
Sandy shale and coal	6	0
Coal ..	4	0
Coal and shale ..	9	0
Coal . .	7	0
Sandy shale ...	10	6
Coal, good ...	9	0
Coal, inferior ...	2	0
Coal, good... ...	11	0
Sandy shale ..	0	2
Coal ...	10	0
White sandstone.		

Nokora.

	Feet.	Inch.
Black shale	1	6
Coal	4	0
Sandy shale, with a trace of coal	2	10
Coal	3	6
Dark sandy shale ...	5	4
Coaly shale with coal (bad coal)	3	6
Black shale	16	10
Coal, inferior	4	0
Coal	5	0
Sandstone mixed with shale	5	0
Very dark shale	3	0
Dark sandy shale ...	2	10
Coal	21	8
White sandy shale	0	2
Coal	13	0
White sandstone ...	7	8

These borings are about $1\frac{1}{2}$ mile from each other; they are beyond a shadow of doubt in the same general beds and the same coals, whereas the very great amount of change in the thickness and character of the seams within this short distance is very evident. This is a very important point as bearing on the question of the economy of working.

Proceeding northwards, two bore holes were next put down at Telwassa, near the river Wardha. The most southerly of these was intended to prove the beds below the thick coals, and to ascertain, if possible, the actual thickness of rock in this Lower Barákar group. It was carried down to 192 feet, and at this depth, when a few feet more would certainly have reached the Talchir beds below, the mineral lifter was allowed to get jammed, and in attempting to raise it, the steel valve box at the end was forced off and left in the hole, which was then abandoned. Some thin seams of very impure coal were found, as anticipated, just at the base of the series, but nothing worth working.

The second boring was fixed about a mile further to the north, on the east side of the river, and here coal was cut at 68 feet below the surface, (of which 29 were surface soil); and the same series of beds as at Ghúgús, again showing considerable variations, were pierced. Altogether 41 feet of coal of varying quality were cut through in a total depth of 138 feet. (See Annual Report, Records, vol. III, p. 1-1).

Another boring was commenced in the lands of the village of Gowarala, near Bhanduk. This was commenced, under a misapprehension of the instructions given, about half a mile from where it was intended to have been, but was useful, inasmuch as the cutters struck the Talchir rocks immediately under the surface clay, and thus effectually proved the absence of coal there.

Two other borings were put down at points intermediate between the Telwassa borings just alluded to and the pit near Chandur. These were near the villages of Belora and Nilja, both in Berar. Both proved the continuance of the same group of beds of coal and shale, exhibiting quite as markedly as elsewhere the great and sudden variation in its character and sub-divisions.

It was next desirable to prove that the coal found on the Chanda side of the Wardha, and there dipping to the west, did actually extend into the country of Berar on the west of the same river. To the south near the villages of Pipalgaon and Ukni small faults affect the continuity of the rocks, and just opposite the point at which the boring in the Telwassa grounds had been put down, the series has been thrown down to the south of a fault which crosses the river. This has enabled some of the beds higher in the series of beds overlying the coal to be here preserved. And they overlap the coal beds to a greater extent than is seen in the adjoining and more denuded area. To test this part of the field, a bore hole was put down, which, however, was not sufficiently far to the west, to avoid this great overlapping, and which, therefore, only touched the extreme outcrop of the coal beds. Another hole about a mile to the north proved very satisfactorily the entire continuance of the coal beds into the country on the west of the river, or into Berar.

Tracing up the same series of beds further to the north, borings were put down in the lands of Konara. This was in the lower rocks (Barákars) and proved no coal: another boring was put down at Borgaon, also without success. Some three miles further north, a boring was put down on the Berar side of the Wardha at Goari (called also Agashi), but nothing but black coaly shales were found here.

These borings were all in the lower rocks. Still further to the north in Chanda district near the village of Majri, a boring was put down, first to the north of a fault which cuts across the beds there, with a view to proving that side, but without success, and then a second boring was commenced to the south of this fault, where the great overlapping of the beds was partially avoided, and here coal was found at 75 feet from surface, and gave a rough section of—

Dark shale, a little coaly 0·2

Coal 51·8. And having proved this thick coal, we proceeded no further. This thick bed, it must be remembered, is not all fair coal, but is split up with many beds of very varying qualities.

A boring, still in progress, was also put down near Nandori, on the Chanda side of the river to the south of the large area of trap which covers many square miles of country near to and around Wurrora. This thickness of trappean rocks effectually conceals

everything beneath them, and looking to the great irregularity with which the coal rocks are overlapped, and the impossibility of drawing any sound conclusion either as to the place or depth below the surface at which coal might be found, fully justifies our putting the entire of this area out of calculation in estimating the extent or quantity of the coal in these Wardha river fields. A boring will be put down to the north of this large area of trappean rocks where the lower beds are again visible over a small area near Panjoorni, a village about six miles north-west of Wurrora and probably near Wurrora itself. But with this exception there will be little use in testing the rocks further in that part of the field *at present*. It is not at all intended to assert that the coal group does not extend under a considerable part of this area, but if it does so extend, the chances of finding it are so uncertain, and the depth at which it probably occurs so doubtful, and in any case so much greater than in adjoining areas that, for the present at least, the coal even, if found, could not be worked to the same advantage or economy as elsewhere.

A boring has also been put down in the Berar country well into the centre of the field and some six miles in a right line from the river Wardha. This was at a place called Rajur, which is near Naith or Nét, and about ten miles to the north-west of Wún town. This was simply intended to test the continuance of the coal under the upper rocks, which cover the whole surface there. Up to the latest reports, 15 feet of coal had been cut into there, quite sufficient to show satisfactorily that the rocks continue.

Two or three more borings will now prove the whole of this northern part of the field with perfect sufficiency, and with detail quite ample as a basis for commencing the actual work of raising coal.

To the south of Chanda, the sections at Balarpur, where good coal is visible at the water level in the river Wardha, in the territories of His Highness the Nizam or on the west side of the river, have been examined. It was concluded from this examination that there was not much prospect of finding this coal extending into the Chanda district, as it had in all probability been very largely denuded or washed away and its place now filled in with beds of great thickness of alluvial clay and sand, &c. Still borings were put down to test the fact, and the rocks were proved at both sides of a marked fault which crosses the section from north-west to south-east, the rocks being down-thrown on the east, but to what extent it was not possible to calculate from the limited exposure visible. These borings proved the existence of a few thin beds of coal, 1 foot to 1½ feet, but nothing worth working.* The full examination of the northern part of the field had then become so much more urgent that the tools were removed there.

All the country south of Balarpur still remains to be examined. There is a certainty of coal occurring in the Nizam's territories in the area between the Pemgunga and the Wardha, and a few borings are there required to test the thickness and quality of this coal. The area stretching from north to south throughout the district of Chanda from east of Wurrora to Bhanduk and Chanda, and southwards by Balarpur to the Wardha near Kirmirri, is all composed of rocks which belong to series above the coal. It is therefore possible that coal may be found to extend under these rocks and so cover a large area. But there is not a trace of these lower coal bearing rocks *visible* anywhere along the line, excepting close to Chanda town. And as the covering rocks dip sharply to the east all along here a short distance only in that direction would throw the coal so deep below the surface that it could not be profitably worked in competition with the more accessible and more favorably placed coal elsewhere. This area ought to be tested by a series of well selected borings at long intervals, and if coal be proved, as I fully anticipate it will be near to Chanda, the indications should be followed up carefully. There is no surface evidence whatever to guide the observer excepting there. I have already mentioned why the borings at Chanda had been deferred until the monsoon weather. But when they are commenced, it will be needful to exercise a little more geological skill than had been shown before, for the holes which were bored were altogether outside or below the horizon of the thick coal which it was sought to prove!

No other group of beds containing coal in a workable thickness has been traced in the field, and none other probably exists. It has been shown that this group of thick beds of shale and coal maintains a constant horizon in the general series, that it is largely and irregularly overlapped by the beds which succeed it, and that with a great amount of variation

* It is stated (Supp. Gaz. India, Jan. 15, 1870, p. 30,) that 6½ feet of coal were proved at a depth of 120 feet from surface, within half a mile of Balarpur!! None of the records of the borings bear out this assertion.

there is still a constancy and continuance of the beds, which is satisfactory. In the former report I gave the results of assays of the coals raised from each successive foot in the boring at Ghúgús; and I showed also what an admirable general index to the value of the coals such assays were. I have had the same done for the coals cut through at Telwassa, and I now give the results of these assays.* It will be seen that the composition of the coal raised here is very similar to that at Ghúgús, and that, as a whole, the coals are of very second rate quality. As shown by assay (Records, Geological Survey, India, vol. II, pt. 4, p. 99), the uppermost seam at Ghúgús was good bright coal. And so it proved on cutting into it in the pit sunk not far off. But like all the bright clean coals of this lower group, it also turned out very brittle and fragile, so that it would bear carriage badly.†

* ASSAYS OF COAL FROM THE CHANDA DISTRICTS.

From No. 1 Seam passed through at No. 2 Bore hole, Telwassa.

Nos.	Carbon.	Volatile.	Ash.	Nos.	Carbon.	Volatile.	Ash.
1	30·9	29·8	39·3	18	44·4	34·6	21·0
2 ... ... }	42·5	32·3	25·2	19 ...	48·9	30·6	20·5
3 ... ... }				20	49·4	30·4	20·2
4	41·6	32·8	25·6	21	50·3	33·4	16·3
5	34·2	32·3	33·5	22	44·0	31·8	24·2
6	35·1	26·7	38·2	23	50·4	31·8	17·8
7	36·9	26·7	36·4	24	50·2	33·0	16·8
8	33·0	25·4	41·6	25	46·7	32·6	20·7
9	42·4	31·6	26·0	26	51·4	30·6	18·0
10	39·1	29·4	31·5	27	51·3	30·6	18·1
11	43·9	32·3	23·8	28	51·2	32·2	16·6
12	46·2	33·4	20·4	29	53·0	30·4	16·6
13	45·4	33·8	20·8	30	52·3	33·4	14·3
14	43·8	34·2	22·0	31	52·0	32·0	16·0
15	45·9	36·0	18·1	32	48·2	30·2	21·6
16	41·9	34·0	24·1	33	43·8	27·4	28·8
17	37·1	32·2	30·7	34	50·1	30·6	19·3

From No. 2 Seam passed through at No. 2 Bore hole, Telwassa.

Nos.	Carbon.	Volatile.	Ash.	Nos.	Carbon.	Volatile.	Ash.
1	46·3	34·5	19·2	5	44·2	33·5	22·3
2	51·2	32·5	16·3	6	43·2	29·8	27·0
3	43·3	29·0	27·7	7	43·4	31·4	25·2
4	49·3	34·0	16·7	8	47·3	28·6	24·1

All burn similarly to the batch sent last September, *i. e.*, vigorously at first, but after the expulsion of the volatile matter only slowly down to the ash. The ash of all the samples (which has been preserved) is very similar, 25 grains mixed of Nos. 31, 32, 33 and 34 on being treated with sulphuric acid, hydrochloric acid, and carbonate of soda left an insoluble residue of 7·5 grains.

On closely inspecting some of the samples some small fragments of a much superior coal may be perceived. From No. 28, which appeared to contain some of the largest of these, I picked out sufficient to make a separate examination. This gave the following result –

Carbon	62·5
Volatile	34·5
Ash	3·0
	100·0

February 28th, 1870. (Signed) A. TWEEN.

† This brittle coal could be coked with advantage.

The coals below that were very inferior, and much that has subsequently been furnished from the sinking at this pit for the use of the steam boring machine is scarcely worthy of the name of *coal* at all, with difficulty keeping up the fire, and not giving steam at all in sufficient quantity. The present assays show that this is the character of much of the Telwassa coal also. One thing is quite certain that, as pointed out long since, any estimate of value based on the duty obtained from carefully selected coal from these will certainly give a false idea of the average value of the whole; while in any ordinary mode of mining, the irregularity of these better beds, and the certainty that they will not continue for any great distance on the same horizon, will seriously interfere with the economic working of seams of such thickness as those we have shown to occur.

It remains to consider what is the amount of coal which may be considered fairly and economically accessible in these Wardha river coal-fields so far as examined, that is, in other words, in the country lying between the Wardha and Pemgunga rivers in the south and the general outline of the trappean rocks which cover everything on the north. If we take this estimate in two distinct portions, as referring to the east and to the west side of the river Wardha, we can then combine the two to get the general results. In Wún district, to the west of the Wardha, there may be estimated to be about 70 square miles of country under which the thick coal may fairly be presumed to extend, and will probably be found nowhere at a greater depth than 120 yards below surface. Now, from this we must deduct a fair proportion for ground cut up by faults and disturbances, and so not likely to yield very profitable return from the working of the coal. If for this we deduct, say, one-third of the area, we will have 45 square miles yielding coal. The average thickness of coal established by the numerous trials may be taken as nearly 40 feet, that is, of coal, coaly shale and beds of varying character taken as a whole. As I have shown, a very large deduction from this must be made, and I believe that an admission of 20 feet would be not only a maximum thickness of workable coal, but be even too high a figure. But taking this as 20 feet of workable coal over 40 square miles, and assuming 600,000 tons as a fair amount of coal obtained from the square mile per foot in thickness, we have $600{,}000 \times 40 \times 20 = 480$ millions of tons of coal, of such quality as it is, available in East Berar at depths below the surface not exceeding say 60 fathoms.

Passing into Chanda we have equally an area of about one and half square miles near Ghúgús, (making the same allowance for disturbed ground as before), and an area of about five square miles in the north of the field. And as the beds of coal are precisely the same, we take here the same estimate of thickness, *viz.*, 20 feet of workable coal. And proceeding on the same data, we will have, therefore, in Chanda, $600{,}000 \times 6{\cdot}5 \times 20 = 78$ millions of tons. This latter result fully bears out what was stated months since, that there was a very much larger amount of coal available in the 'Assigned Districts' than in Chanda, in the vicinity of the Wardha.

We certainly ought not to estimate more that one-half of these quantities of *good* coal.

While engaged in the practical exploration of these coal-fields, I had frequent applications from the Engineers employed in making trial sections and estimates for a proposed line of railway for information as to the position, quantity, and quality of the coal, and as to the general question, which would be the line best adapted to meet the requirements of the case, so as to facilitate the transport of this coal to the existing lines of railway to the north and southwards to the Godavery. It was also asked that the opening up of the cotton country should be borne in mind. Every information was readily afforded from time to time as new facts were ascertained.

But this necessarily led to the consideration and discussion of the best direction in which to carry a line of railway with these avowed objects. The intended point of junction with the Bombay and Nagpúr line was stated to be the Wardha station, and it was at first assumed that the line *must* go to Chanda or through the Chanda district. Long since I pointed out that it required but a very trifling acquaintance with the country to show that by much a larger area of coal existed in Berar than in Chanda, and that it was simply misleading opinion to speak of this coal-field as the Chanda coal-field. I also had occasion to show that the pit which was being sunk to the coal near Ghúgús was quite unnecessary if it were only intended as a means of trial of the coal, and that if intended as a means of working

the coal afterwards, it was injudiciously placed, and must be for years to come superseded by others more conveniently located. Such general considerations, however, based on a view of the field at large were of little avail, as compared with 'practical' views, and the work was hastily pushed on. It is to be hoped that the fact, that the Geological Survey have since then pointed out the exact localities for borings and have thus proved the existence of coal within a few feet of the surface, where, they were told, 'such trials were only foolish blunders,' evincing an 'utter ignorance of the teachings of Mining,' and were 'at places where it was impossible that coal could exist,' will be a warning to future enquirers in their researches, and that they will at least try to make themselves acquainted with the geological structure of the area they are about to examine before they trust to preconceived notions or permit themselves to be swayed in their investigation of facts by personal wishes or local tendencies.

The facts stated above are sufficient to show that if the object of a proposed line of railway be to accommodate the largest amount of *coal* traffic, there cannot be a shadow of doubt that that line of railway should go right into the middle of the Wún district.

The consideration next in importance to the establishment of a free communication with the coal-fields was stated to be 'the opening out of the Hingunghat cotton country.'

But what is the Hingunghat cotton country? By much the larger portion of the cotton, which now finds its market at Hingunghat, and all of which is shipped or sent away as Hingunghat cotton, is not grown in the immediate vicinity of Hingunghat, but is brought from very considerable distances. Previously to the opening of the Nagpúr branch of the Great Indian Peninsular Railway, a large share of its supplies was drawn from the country to the north and north-west of the place, and much excellent cotton was brought to Hingunghat, even from Arwee, 50 miles to the north-west, and from the districts in that direction. All this cotton now finds its natural outlet at the nearer marts of Wardha and other places on the line of railway, and scarcely a load, as might have been anticipated, crosses this new line of communication to reach Hingunghat on the south. The country lying between Hingunghat and Wardha must also naturally seek the nearest markets for its produce. For the Hingunghat market, therefore, the supplies must now be derived from the south, south-east, and south-west. But to the south-east, and partly to the south, on the east of the river Wardha, with the exception of a small area near to the town, the country is almost an unbroken jungle for hundreds of square miles. The so-called 'southern road,' although it passes very near to the large towns of Wurrora and Bhanduk, scarcely touches even isolated patches of cultivation for its entire length from near Hingunghat to near Chanda, and again south and south-east of Chanda it sweeps for mile after mile through dense jungle. This belt of forest jungle is in places 30 to 40 miles wide from east to west, and not only does this immense area not yield any cotton at the present, but it is of such a nature that no reasonable hope of its ever producing cotton profitably can be entertained. The surface deposits are derived from the decomposition of coarse ferruginous sandstones and other silicious rocks, which yield a dry thirsty sandy soil, in which the cotton plants cannot flourish. Between this immense range of forests, yielding little but mere jungle produce, and the Wardha river there is a belt of open ground varying in width from two to ten miles, over which are spread thick deposits of alluvial clay and occasionally regur in which a fair amount of cotton is grown. But, as shown, this area is very limited, and the amount of produce must be equally so. On the other hand, to the west of the Wardha, the country is open and cultivated, and produces largely of cotton over an area very many times the extent of the possible cotton yielding country of Chanda. And besides this large area in Berar itself, immediately adjoining to it on the south, is the rich and well known district of Edlabad in His Highness the Nizam's territories, from which, even at present, with all the difficulties of long land carriage (at least 60 miles to Hingunghat) and heavy rivers to cross, by much the most valuable portion of the 'Hingunghat cotton' is obtained. I was led to these considerations myself while engaged in the careful examination of the country (and few persons, if any, see the country with the same detail that geologists do), but I have also been confirmed in this view by those actually engaged in the cotton trade, and who, therefore, were personally able to ascertain the facts. Mr. F. Curwen, agent for Warwick and Company, by far the largest dealers in Hingunghat cotton, stated to me on enquiry that he had given particular attention to this important question of *where* the cotton which came to that market was grown, and had ascertained that taking the ordinary annual sales at Hingunghat as about 30,000 bales, not more than 2,000 out of that quantity were the produce of land

near the town, and to the south and south-east of it on the left side of the Wardha river; by far the largest portion and the best quality coming from the Nizam's territories (Edlabad. &c.,) and from East Berar.*

Equally, therefore, if the object be to open out this valuable cotton yielding country by a line of railway, that railway must be carried through East Berar and to the west of the Wardha.

At present the route commonly taken by the carts bringing cotton to Hingunghat is through Wún, crossing the Wardha river to the south-west of Wurrora, and passing through that town to Hingunghat. In this way it is 'that strings of cotton carts may be seen making their way to Hingunghat,' but a very small portion indeed of their loads is derived from Wurrora or Chanda, or any place on the east of the river.

These facts also account for the small and 'not increasing' cotton trade at Wurrora, which is too near to the larger and more important mart of Hingunghat and too far from the main source of the raw cotton to absorb much of the trade. There can be no doubt that if once railway communication be opened up into the Wún and Edlabad country, new marts and presses for cotton will rapidly spring up in more immediate proximity to the places of growth of the crop, where the risks of injury from exposure on open carts and from delays in bringing to sale will be reduced to a minimum. And in this point of view, it may be well deserving of consideration whether the necessarily reduced trade of Hingunghat will then repay the cost of construction of a branch line of railway.

Other special objects to be gained by the construction of a branch line of railway were stated to be the utilization of the timber forest of Aheree and the connection of the Godavery navigation with Central India. To accomplish either of these objects, it is essential that the proposed line should be carried as far to the south as the bottom of the third barrier on the Godavery river, or to the town of Mogéli, or rather Talye or Talawye, on the west, or of Dewalmurri on the east of the Pranhita. To accomplish this, it was proposed to carry on the line, which it was assumed would go to Chanda town, to Kirmirri, where a sound rocky† foundation for a bridge would be obtained, and crossing the Pranhita there to proceed to Mogéli, on the opposite or west bank of the river. How the timber of Aheree which lies away from the river on the east side was to reach the railway on the west I know not. But there is little need to discuss this, for the surface of the country to the south of Chanda town offers physical difficulties, which will prevent any economical construction of a line of railway there. The line, alluded to above, if carried into East Berar could, on the other hand, be prolonged to Mogéli, or Talye, without meeting with any equally serious difficulty. It could cross the Pemgunga above the junction of the Wardha, where the body of water and the cost of bridge would not be one-half of what it is at Kirmirri, and where it would be close to coal.

Exactly the same arguments suggest themselves if we consider the connection of the Godavery navigation with Central India, to accomplish which, the main point would, of course, be to obtain the cheapest and best road to the bottom of the third barrier. But to these may also be added the fact, that there is every prospect of a considerable area of coal in the Nizam's territories between the Pemgunga and the Pranhita, all of which would be economized by a line of railway on that side of the Pranhita, but would be useless or nearly useless if that communication were carried out on the opposite bank, where no coal occurs.

Any advantages anticipated from the introduction of the Wardha coal into the southern parts of the Peninsula (Madras, Hyderabad, &c.,) would be common to either line. But these may be, I think, put out of present consideration altogether. If, on further investigation, the coal known to occur near Dumagudium and to the south of that place prove abundant

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* The Tehsildar of Wún reports that the ground under cotton cultivation this year was 28,177 acres: the average produce for each acre was 76¾lbs., the total produce 1,077,770 seers = 9,000 bojas, or 18,000 guttas (bales). Besides the above, about 12,000 bojas, or 24,000 guttas, are carried through this taluq to Hingunghat from His Highness the Nizam's territories, from Rajur, Manikgur, and Edlabad taluqs.—*April* 1870.

† It is a singularly perverted misapplication of a tolerably well known geological term to speak of the wide spread area of crystalline rocks which are exposed at Kirmirri and to the east as a "gneiss dyke." The only real use of such special terms is to convey accurate ideas without the necessity of long descriptions, but if employed when their meaning is not known they must have exactly the opposite effect, and must lead to confusion and obscurity.

and of fair quality, there would be no hope of contending with that field for the supply of Madras or elsewhere to the south. And it is greatly to be regretted that Colonel Haig was not supplied with the means of investigating this very important question during the present year. And in any case coal does occur many miles to the south of the Chanda coal in the Nizam's territories, which is much more conveniently placed for meeting any demands from the south.

Other considerations have been introduced incidentally as it were, which may be just alluded to. 'The rich iron ores of Chanda would before long,' it is said, 'be smelted at foundries near the coal-field.' Whether such a rapid introduction of iron works can fairly be looked for under any circumstances is more than questionable. That rich iron ores do exist in the Chanda district is well known, and equally that they exist in practically exhaustless quantity (there is a whole mountain nearly a mile long of magnetite in one place), but these ores do *not* occur near the coal-fields. There is also hæmatite ore in the Yanak hills, near to where the line of railway if carried down there ought to cross the Pemgunga, and near to coal.

In all these remarks I would say that I have purposely avoided entering on any question of the comparative facilities, or comparative economy of construction of any such line. Some years' experience in laying out and making railways might justify my discussing these points, but I have known so many instances of absurd mistakes as regards sections and estimates for such works based on a mere inspection of the ground, or put together on the information of others only, that I would not venture to offer an opinion without actual survey. Nor is there any necessity to do so. Trial sections have, I believe, been taken over both the lines referred to, and I am much mistaken if these sections have not shown how entirely below the mark the first estimate of the cost was. But, *cæteris paribus*, I merely wish to assert, that a line of communication direct from Wardha into East Berar will accommodate any likely traffic in coal, and will open out the cotton country infinitely better than a line direct to Chanda, or through the Chanda district.

I cannot close without noticing how much, in my opinion, this matter has been obscured by the unhesitating adoption of the term of the Chanda coal-field. It so happens that just there the territory immediately adjoining is under a separate government, and belongs to a different jurisdiction, and the very existence almost of the Berars has been scarcely alluded to in discussing lines of communication, which were to be designed for the benefit of the country at large. But geological formations are not coincident with political boundaries fixed for the convenience of man. Such examinations acknowledge no fiscal limits; we have but to ascertain the facts carefully, and then to state them freely, convinced that any attempt to force the teachings of those facts into a preconceived groove of local tendencies must fail sooner or later, as does every such effort to run counter to the laws of nature.

Whether even the large extent of coal proved to exist in Berar, of a quality such as it is shown to be, and varying so much as it does at different points, will repay the charges for construction of a line of railway, is, I think, worthy of much closer consideration than it has yet received. The calculations which have been gone into in great detail, although correct in themselves, are based on data, which even the few weeks that have since elapsed show to be fallacious. English coal was taken as costing at Bombay *on an average* Rs. 30 per ton; at Nagpúr Rs. 60 to Rs. 70. And it was calculated, even allowing for the use of two tons of local coal instead of one of English, that at any place east of Bhosawul a saving of £1 6*s*., or Rs. 13 per ton, would be effected by the use of Ghúgús coal. The price of English coal at Bombay is now, April 1870, Rs. 14 per ton, that is, less than one-half the price calculated, or a difference in first cost greater than the estimated saving!! I do not believe that this rate can be maintained, but it is quite possible that the continued use of the Suez Canal will tend to reduce very considerably the average cost of English coal at Bombay.

This one item alone would totally upset all the calculations of cost, of profit, and of traffic even. And before it can be asserted that a branch line of railway to the Wardha river coal-fields will even repay interest on the cost of its construction, vastly more careful and more widely gathered statistics, both as to cost and amount of traffic than have as yet been hastily procured, or at least published, must be sought for.

May 1*st*, 1870. T. OLDHAM.

REPORT ON THE COAL AT KORBA IN THE BILASPUR DISTRICT, by W. T. BLANFORD, Esq., F. G. S., Ass., ROYAL SCHOOL OF MINES, Dep. Supdt., Geological Survey of India.

1. *Locality and mode of outcrop.*—The village of Korba is situated in the eastern part of the Bilaspúr district belonging to the Chhatisgarh (Chutteesgurh) division of the Central Provinces, and is the residence of a zemindar who owns a large portion of the surrounding country. It lies on the left or eastern bank of the Hasdo river, a large tributary of the Mahanaddi. This stream has in most places a broad sandy bed, varying, however, from about 200 yards to above half a mile in breadth. The country around Korba for many miles in all directions is flat or very gently undulating and usually covered with clay.

Coal is exposed in two places close to the right (western) bank of the river just below Korba. The exposures are in the bed of the river, no section being seen in the bank itself, and, as will presently be shown, it is probable that both belong to the same seam of coal. A very slight rise in the river is sufficient to conceal both outcrops.

The lower outcrop, which is about half a mile below the village, is the best suited for examination, as both the top and bottom of the seam are exposed. A considerable proportion of the section is above water during the dry season, although there is always a great thickness concealed. The seam is remarkably thick, but owing to its mode of occurrence it is impossible to measure it exactly. It may, however, be computed sufficiently closely for all practical purposes. The dip varies in inclination from 13° to about 18°, and in direction from N.-30°-E., at the northern extremity of the section, to N.-16°-E. at the southern end. The horizontal breadth of the outcrop at right angles to the strike is 350 feet, and, taking the average dip at 15,° the corresponding thickness is 90 feet. This, I believe, is rather below the truth than in excess of it.

Both above and below the coal massive felspathic sandstones occur. Below the seam but a small thickness of these rocks is exposed, but above it at least 400 or 500 feet are seen in the river.

2. *Section of Coal seam and quality of Coal.*—Of course the great thickness already mentioned does not consist throughout of workable coal. Bands of shale and of inferior coal are interspersed, as is more or less the case with most Indian coal seams. From the imperfect manner in which the seam is exposed, especially towards the base and from the surface, as usually happens in similar positions, being extensively decomposed, it is impossible to obtain a correct idea of the quality of the coal without cutting into it. I consequently had a series of small pits dug, six to seven feet deep, and from these and the portions of the seam fairly seen in the river bed, I obtained a good section of the whole thickness with the exception of about ten feet. To examine these few feet would have caused some delay with the means at my disposal, and I had already fully ascertained the existence of a large proportion of good coal.

The section of the seam thus ascertained is the following. Of all the bands of coal to which letters are attached specimens have been transmitted to Calcutta for analysis :—

Sandstone.	*Feet.*	*Inch.*		
Shale, about ...	1	0		
Coal of fair quality ...	1	0		
Inferior *coal* ...	1	0		
Shale and inferior *coal* ...	3	3		
Good *coal*, an inch or two of inferior coal here and there ...	3	9	*a*	
Good *coal*... ...	6	0	*b*	
Shale and *coal* mixed ...	1	6		
Good *coal*... ...	3	0	*c*	
Shale with bands of *coal* ...	3	6		
Good *coal*... ...	4	0	*d*	
Coal and shale mixed ...	2	0		
Shale with bands of coal ...	2	0		
Coal of fair quality ...	1	6		
Inferior *coal* ...	0	6		
Good *coal*... ...	5	6	*e*	
Shale ...	0	6		
Coal ...	0	3		
Shale ...	2	0		
Coal ...	1	0		
Shale and inferior *coal* ...	2	0		
				45 3
Carried over				45 3

Sandstone.	*Feet.*	*Inch.*	
Brought forward	45	3	
Good *coal*	4	0 *f*	
Shale with bands of *coal*	3	0	
Shale and *coal*, the latter good in part	3	0	
Coal rather inferior in part, but generally good	3	6	
Shale	1	0	
Good *coal*	1	0	
Not examined, about...	3	0	
Shale	1	0	
Good *coal*	4	6 *g*	
Not examined, about..	3	0	
Good *coal*	4	0	
Shale	0	4	
Good *coal* containing one or two thin bands of shale	6	8 *i*	
Not examined, about...	3	0	
Shale	0	4	
Good *coal*...	2	8 *j*	
			89
Sandy shale			
Sandstone			

The above section shows a *minimum* thickness of 50 feet of fair coal. The proportion is probably nearer two-thirds of the seam. The best bands appear to be those marked *b*, *g*, and *h*; portions of these and especially the lower two feet of *h* * appeared to me equal in quality to any coal found in the Raniguuj field. There is some iron pyrites here and there, but not throughout. The coal ignites readily and burns well with rather more flame than is usual in Indian coal obtained from the surface. The ash left is large in quantity and partly red, partly white.

Probable extent of seam.—Metamorphic rocks are seen in the Hasdo about three miles south of Korba, and also at about the same distance to the north: these mark the limits of the beds accompanying the coal in those directions. East and west the coal-bearing beds extend to a great distance, and to the north-east they are apparently continuous with those forming the hills east of Chúri and Sutringa, and these are probably part of one large field which has been found by Mr. Medlicott to extend beyond Sirgúja. But unfortunately the surface of the country near Korba is so much covered with alluvial deposits that very few rocks are visible, and those seen are almost invariably coarse sandstones, the dip of which can rarely be determined accurately. West of the Hasdo the concealment is even greater than to the east, while in the latter direction the whole country is an immense forest, rendering the relative position of the few outcrops met with very obscure.

But little information can be derived from the rocks seen in the Hasdo. The second outcrop of coal occurs about 300 yards higher up the river than that already described, and close to the same (right) bank. It is distinctly seen to be faulted against the sandstones which overlie the coal exposed at the southern outcrop. About 50 feet of coal are exposed, neither the top nor the base of the seam being visible. The dip is very irregular and twisted owing to the fault close by; it averages about 12° to N.-10°-W.

It appears more probable that this is the same seam as that seen a little further down the river, and that it is brought up again by the fault than that two seams of such unusual thickness should occur in the same beds. This, however, can only be decided positively by boring. The coal at the more northern outcrop appears rather inferior to that seen to the south, but in the latter locality the central portion of the seam contains more shale and inferior coal than the top and bottom, and it is the central portion of the seam which alone is exposed to the north. If the two outcrops belong to the same seam the fault has a down-throw on its eastern side of no great amount, probably not much above 100 feet.

So far as any reliance can be placed upon the dips in the sandstones, the general direction appears to be north by east to north-north-east for about a mile up the river above the coal. Beyond this no rocks are seen. Just above the village of Korba on the left bank there is a reversed dip to the south-west, but it is probably local.

Below the southern outcrop rock is only seen in the river at distant intervals; the few sections observed appear to indicate that the direction of the dip changes to the eastward.

* By a rough experiment, I obtained very fair coke from this part of the seam.

In this case the outcrop of the seam may pass for a long distance down the river, being concealed by the sand in the bed, which is here of great width. All dips seen appear to be lower than those at the outcrop of the coal, and it is highly probable that the amount of inclination may be higher at this spot than it is elsewhere, and the direction of the dip different in consequence of the fault close by. The circumstance already mentioned of the variation in both amount and direction of dip at different parts of the outcrops in the coal seam itself is in favor of this view.

So far as an opinion can be formed on these very imperfect data, it appears that the rocks associated with the coal cover a large tract of country, and it is improbable that so thick a seam should thin out within a short distance. It is, however, quite in accordance with our knowledge of similar seams in other parts of India that the exact thickness, the quality of the coal, and the proportion of good coal to inferior coal and shale should be highly variable.

If the coal seam be continuous it should be found west of the Hasdo throughout a tract from one to two miles broad, extending probably in a west-north-western direction from the river, the southern boundary of this tract passing through the more northern of the two outcrops seen in the river. East of the stream the seam should underlie the village of Korba and the river bank for at least a mile below and probably one to two miles above the village, and it may extend for an indefinite distance to the eastward, but it is possibly at a considerable depth below the surface throughout a large proportion of the area.

It is evident that before attempting to open a coal mine, boring must be resorted to in order to ascertain the extent of the seam and its depth beneath the surface. The best places for boring will depend upon whether it is desirable that the coal should be extracted on the east or on the west side of the Hasdo.*

If to the west, as the strike of the rocks is somewhat uncertain, the first boring should be made about a quarter of a mile west-north-west of the spot where the more northern outcrop appears in the river. Although the strike at the outcrop is west by south, there can be but little doubt that the normal strike is north of west, and that the alteration is due to the fault. Should the coal not be found in the first boring within a depth of 200 feet, two others, one 300 yards further north, the other at the same distance to the south, should be made. When the true direction of the outcrop is ascertained, it will be well to continue the borings along it at distances not exceeding half a mile apart, as any slight change of direction coupled with the high dip (if the latter be constant) will take the coal below the depth to which borings can most conveniently be made. There is also a possibility of other faults occurring besides that seen in the river.

On the east of the Hasdo the question is simpler. The fault so frequently referred to must either pass through the village of Korba or just south-east of it. West of the fault a boring behind the zemindar's residence would probably pass through the seam. East of the fault the best place for boring is at a spot where sandstone occurs in the left bank of the river below Korba, due east of the more southern outcrop on the right bank. Owing to the rather high dip, these borings should be made to a depth of about 400 feet, if coal be not found sooner. But, as I have already suggested, it is far from improbable that the high dip is local, and that on the left bank of the Hasdo the inclination is less, in which case the coal may be found at a moderate depth. Other borings, if the above are successful, may be made at intervals along the east bank of the stream below Korba. To the north of Korba the coal for some distance is probably at a considerable depth, but if continuous, it must again rise towards the surface between one and two miles north of Korba. It is, however, impossible to indicate with accuracy a good spot for boring in this direction. The best plan for examining the ground would be to put down a series of borings along a line running north-north-east from Korba at half mile intervals.

Facilities for mining.—The dip of the seam where seen in the river, although considerable, is by no means so high as to be any impediment to mining beyond its effect in rapidly increasing the depth of the seam below the surface. The sandstone above

* In case of a railway bridge being necessary across the Hasdo, Korba appears to be a more favorable spot than any other in the neighbourhood, as the breadth of the river is moderate and a considerable portion of the channel rocky. For several miles above and below, the breadth is very much greater, and the bed a wide expanse of sand.

the coal is firm and massive, and will probably furnish a good roof. The coal appears compact, the joints or "backs" are rather irregular, but still sufficiently marked in general to facilitate mining. Some of the very best and brightest coal is as usual rather brittle, but the greater portion of the seam bears carriage well. This bright coal, as I have mentioned, makes a very fair coke, and in that state is far less brittle, besides being much lighter and consequently costing less for carriage. The cost of coking in ovens heated by waste coal would be very trifling.

In consequence of the absence of bands of shale in the overlying sandstone, the quantity of water may be rather larger than usual, but in the small pits dug in the bed of the river the coal did not appear in general to be porous.

In mining a seam of such thickness as this, especially where the proportion of good coal is large, if the roof prove as sound as will probably be the case, it will be an important economic question whether some more advantageous method of mining cannot be adopted than that of removing a small section of the seam, not exceeding twelve feet in height, by "long wall" or still worse by "post and stall," more especially as it is highly improbable that the best bands of coal will be found for any distance on the same horizon, a most serious draw-back to mining on either of the two English systems mentioned. It would, however, be premature to enter into this subject at present, but the methods adopted for extracting the thick deposits of lignite or brown coal found in parts of Germany are deserving of attention.

Conclusion.—I have endeavoured to show my reasons for the opinion I have formed as to the Korba coal. My conclusions are briefly, that both the quality and mode of occurrence are favorable. In thickness, in quality, and in the proportion of good coal to inferior coal and shale, the seam surpasses that near Chanda. The question of the extent over which the coal extends must be ascertained by boring.

CAMP KORBA,
18*th April* 1870.

The following table gives the result of assay of the coals referred to in Mr. Blanford's report just given:—

	Carbon.	Volatile.	Ash.		Carbon.	Volatile.	Ash.
a	38·7	26·6	34·7	*g*	46·4	23·6	30·
b	45·8	22·4	31·8	*h*	57·5	25·2	17·3
c	42·3	25·2	32·5	*h* lower 2 ft. *	60·5	29·5	10·
d	39·6	24·6	35·8	*i*	46·5	22·2	31·3
e	47·8	28·2	24·	*j*	53·3	27·2	19·5
f	32·8	21·4	45·8				

9*th May* 1870.

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* Cakes slightly.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 3.] 1870 [August.

THE MOHPANI COAL-FIELD, by H. B. MEDLICOTT, M. A., F. G. S., Deputy Superintendent, Geological Survey of India.

Sketch-map of 1859.—Any one who has examined with attention the sketch-map of the middle Narbadá region, published in 1859 by the Geological Survey of India, must have noticed how few actual coal-crops are marked in the large area colored as possibly coal-bearing; and more especially, how very partially those outcrops are distributed in that area. With the exception of Mohpani, and the less known case near Lokartalai, all the observed coal-localities occur close to the south border of the basin of stratified rocks, far from the Narbadá valley, on the south tributaries of the Upper Tawa and in the valley of the Pench river. A reference to the index of colours on the sketch-map, and to the descriptive text (Vol. II., Mem., Geological Survey, India,) would suggest possible explanations of these peculiarities: two groups or formations, the Damúda and the Talchir, are mapped under one colour. It was known at the time (see. p. 149, etc.) that the coal is confined to the upper group; but the demarcation between the two is very obscure in this region, and it would have been at that time impracticable to have undertaken to separate them, as no sufficiently accurate map of the country was to be had. Another possible explanation of the anomalous distribution to which I have drawn attention is suggested by the somewhat doubtful boundary between the Damúda group and the overlying strata of the Mahadéva series, as noticed at page 191 and elsewhere—the possibility that some of the latter may have been locally included with the former, thus unduly enlarging the apparent area of the coal-bearing rocks.

It has long been the desire of the Superintendent of the Geological Survey to clear up all these known doubts, more especially with reference to the very pressing question of the coal-supply to the railway that now passes close along the northern margin of this area. The much increased knowledge of all these rocks that has been attained within the last few years will greatly facilitate the final separation of the groups; and thus definite information will be available for the guidance of mining experiments. The detailed topographical survey of this region is now nearly completed; and proof copies before publication of some of the sheets having been obligingly supplied from the Surveyor General's Office, the revision of the geological work was commenced in November last. It will be some time before the detailed examination of so large an area can be completed; but some definite results have been already obtained, bearing very importantly upon the question of the coal-supply and the proper direction for further mining explorations.

Alterations to be made.—To any who have not applied the necessary reservations to the indications of the sketch-map, the present information will be somewhat disappointing. It is still to be expected that coal will be found where it is not now known; but observations made this year greatly reduce the area to which such hopes can be applied with any confidence; the negative indications of the sketch-map have been substantiated by the verification of the surmises that have just been pointed out regarding them. The case may be very briefly stated, and easily understood by a reference to the old map: the whole of the Dhúdhi valley, and all the valley of the Denwa (or Deor) north of the Pachmari range, are formed of rocks belonging to the Mahadéva series,* in which there is no prospect whatever of coal; although it may occur beneath them. A note on the sketch-map indicates the

* In the report under notice the name Mahadéva is used as that of a single group; but recent investigations here and elsewhere tend to show that it comprises several groups, for which collectively the name may perhaps be retained. It would be out of place to discuss the question in the present report.

doubts that were entertained regarding the Deor valley. To the south of the Pachmari range, including a large portion of the plain of the Tawa, the rocks, although belonging to the Damúda series, are certainly higher than the true coal-bearing group of this part of India; they are throughout more or less carbonaceous, and contain the Damúda fossil plants; and there is therefore always a chance of coal occurring in them, as will be fully tested by the detailed survey; but every distinct indication of coal at present known throughout the entire region (with the exception of a poor Mahadéva coal to be noticed presently) is referrible to a thin band at the base of these rocks, immediately overlying the Talchir group, and outcropping near the margin of the basin, as indicated on the sketch-map. This restriction of the apparently large area of the coal-bearing rocks brings into greater importance the limited fields that are known, and suggests the close search for similar small outcrops of the measures along the edge of the basin.

The Mohpani field.—The wide separation, by intervening barren (coal-less) rocks, of the several localities where coal appears at the surface within the large area hitherto generally referred to in this connection as the Narbadá coal-basin necessitates the recognition of as many distinct coal-fields. Of these, the Mohpani field is at present by far the most important, on account of its accessible position, and because the value of the seams has been proved by actual mining. It is situated at the south edge of the Narbadá plains, twelve miles from the Great Indian Peninsula Railway at Garrarwarra, and is traversed by the Sitariva river, in which the entire section is exposed in a length of about a mile and a half. On the south the measures are buried beneath lofty hills of younger rocks; and on the east, from the sharp bend of the river, the field is rapidly cut off by an overlap of those same strata. To the west the extent of the field is very obscure and doubtful: for seven miles from the Sitariva the ground is very much covered, the talus from the ridge to the south of the measures being confluent with the superficial deposits of the plains, so that only a few small and uncertain outcrops can be seen. A little further west, however, in the Dharajhor, a complete section is obtained up to the metamorphic rocks at the edge of the basin; and the coal-measures are there altogether covered and overlapped, the whole ground being occupied by the younger rocks. Thus the possible limits of the field as appearing at the surface are very restricted; and we have no certain knowledge of it beyond the much smaller area bordering the Sitariva. A description of this locality will be the best guide to the experimental investigation of the rest and of the possible extension of the field by working the measures through overlying formations. The accompanying map, copied from the new Revenue Survey sheets, is not on a sufficiently large scale to express on it the detail that would be desirable for such a purpose; but it will at least make the case intelligible: the little map on the one inch to the mile scale shows all that is visible of the coal-measures in this field; the larger map shows the area over which the measures may outcrop; beyond that area they must be sought through other rocks.

Actual observations very limited.—Although it is now several years since mining was commenced by the Narbadá Company, very little has been done to explore the field; all the workings are on one spot close to the outcrop in the river. Two or three borings were made in the immediate neighbourhood, but without cutting the coal, as will be accounted for presently. The Sitariva Company have been too busy opening their pits, close upon the northern outcrop in the river, to have had time for further explorations. Thus, for a description of the field and its extent there is little more data than that available from the natural outcrops. The extent of this information and of the field as at present known may be judged from the statement that one square mile would very nearly include all the localities where coal is visible; and fully one-half of that square mile is occupied by rocks below the coal-measures. It may indeed be confidently expected that the coal exists and can be followed over a much larger area; but it needs no more at present to show how impossible it would be to arrive at a correct estimate of the extent or value of the field until further trials have been made.

Formations:—There are three formations to be considered: the Mahadéva series, the Barákar group (or the coal-measures), and the Talchir group; besides trap-rock, metamorphic rocks, and the superficial clays and gravels, or 'wash-drift':—

Mahadéva Series.—The Mahadéva series is of great thickness, and comprises a large variety of rocks; but as here exposed, at and near the contact with the coal-measures, it maintains very constant characters, being formed of massive coarse conglomerates, sandy or earthy, and generally more or less rusty; with these are freely but capriciously associated beds of deep red clay sometimes mottled and calcareous, or even with nodular layers of limestone. Courses of rusty sandstone are comparatively rare here. These rocks form the base of the lofty ridge of Nimúgarh, as well as the smaller hills bounding the field on the east;

and they are the last rocks seen at the north end of the section in the river. On the tops of the hills, and generally at a distance from the edge of the basin, the Mahadéva formation is largely composed of sandstones above, associated with earthy beds below.

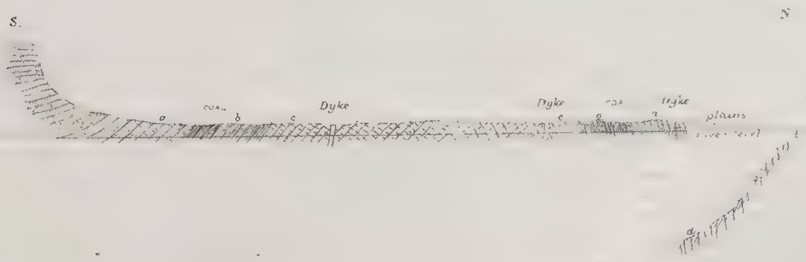
Mahadéva coal.—It is important to notice here the coal that occurs in this formation. Much labor and expense have already been devoted to it; and I am aware that hopes are still entertained of it by intending speculators. Without wishing to deter men finally from exploring what may possibly in some local instance turn out a good thing, it is but right that all should be informed of what is known regarding it. Many thousand maunds of this coal were cut by Mr. Walker, contractor for the Narbadá bridge, at Laméta ghat on the Narbadá, and profitably used for lime and brick-burning. Some was also extracted on the Sher river near Sehora. The same coal has been examined in many other places, as in the Mahanudi, to the north-east of Jabalpúr; in the Hard river, a tributary of the Sakkur; on the flanks of Nimúgarh, south of Mohpani. Many years ago this coal was cut in sinking a well within the station of Jabalpúr. Its characters are everywhere the same,—a bright jetty lignite-coal, disseminated in threads more or less abundantly in thick shale and sandstone; the proportion of coal is exceedingly variable, and, except in rare cases, altogether too small for use. In the nearly continuous rock-section in the Sher and Machariva rivers, this coal is exposed ten or twelve times in a length of as many miles, without any change of character, and offering no encouragement to any attempt at mining. It certainly would not bear transport or keeping; and the most that can ever be expected of it is for local use for rough purposes.

To one who is not familiar with the characters of these formations, and accustomed to discriminate between varieties of similar rocks, this Mahadéva coal-band might readily pass for the true coal-measures, as it often occupies an analogous physical position at the edge of the plains. The simplest criterion is the coal itself, which is quite unlike the Damúda (Barákar) coal. Although found in so many distant localities, the coal-band is certainly not a constant member of the series; nor is it even likely that all the known seams are on the same horizon in the series.

Barákar group.—The Barákar group is not more than 500 to 600 feet thick, composed of strong beds of gray and white felspathic sandstone, alternating near the top with carbonaceous shales and coal-beds. Wherever the section is exposed in the neighbourhood of the Sitariva, these beds are found close beneath the bottom red clays or conglomerates of the Mahadévas.

Talchir group.—The Talchir group is typically characterised by beds of fine greenish silt, or silicious clay and sandstones, in either or both of which pebbles and boulders, often of large size, are thinly scattered. The fine earthy sandstones pass up by imperceptible gradation into the Barákar rock, so that the boundary between them, in the absence of characteristic fossils, must often be arbitrarily assigned. These rocks occupy a large space between the north and south outcrops of the coal-measures on the Sitariva.

Structure of the rocks.—The general section (see figure) north and south across the field will illustrate the relations of the rock-groups and explain the present structure. There is no



General section from south to north, across the Mohpani coal-field.

Scale, 2 inches = 1 mile. *a*, Mahadéva: *b*, coal-measures: *c*, Talchir: *d*, metamorphic.

The dotted lines indicate the probable mode of extinction of the coal-measures to the north.

other locality known where the coal-measures are so much broken as in this field. In the section of the Sitariva, the general character of the disturbance is a normal anticlinal flexure, having moderate dips on the south, but rising to the vertical on the north side of the axis; the last rock seen next the superficial gravels of the plains being vertical beds of the coarse Mahadéva conglomerate. There are numerous minor contortions and dips that are not attempted to be represented in the figure. In an easterly direction from the river, the contortion dies out rapidly; the vertical seams of the northern outcrop flatten and bend southwards, passing round into continuation with the measures on the south of the flexure. The Talchirs are thus covered up at the surface; and, on the other hand, the Mahadévas stretch continuously to the edge of the plains; at Pukuhi they still have a low south-easterly dip, but soon become quite horizontal. In a westerly direction the main feature of the disturbance seems to continue for some distance, as is shown by the steady south-south-east dip of the conglomerate along the base of the Nimúgarh ridge; but this regularity does not obtain along the axis of the flexure, as is shown by the few outcrops that are visible to the north of the ridge. At the west base of the outlying hill of trap near Mohpani, in about the position of the axis of the anticlinal, the coal-measure strata have a steady low easterly dip. This irregularity greatly complicates the attempt to search for such outlying masses of the coal-measures as may exist beneath the superficial gravels at the foot of the hills.

Trap-rock.—Trap-rock forms an important consideration in he valuation of this field. It occurs both in dykes and in overlying masses, but is all of the same description,—a dense basaltic rock; and, as far as present evidence goes, it may be all of the same age. There are three great dykes in the Sitariva: the first is at the very northern edge of the rock-section; it is about twenty yards wide, running through the Mahadéva conglomerate very nearly along the vertical bedding, with a strike of 5° south of west, and a slight southerly underlie. The second dyke is in the Talchirs, oblique to the bedding, some fifteen yards wide, with a strike to 20° north of west, and a slight southerly underlie. The third is also in the Talchirs, about twenty yards wide, running nearly due east and west, and with a very slight southerly underlie. Although all these are remarkably steady for the short length seen in the river banks, they certainly do not continue so, as a rule, for any distance. It is probable that No. 1 represents, or is even continuous with, the strong dyke that is found at or near the base of the hills to the eastwards; but its course must be more or less tortuous. At three miles to the east, in the river's bank just above Dongarkho, there is a very pretty section showing how suddenly these trap dykes may stop out on the rise: at the water's edge the dyke is some twenty yards wide, and all trap; at a height of fifteen feet there is hardly a trace of it to be found, the whole having split up and rapidly thinned out between thick wedges of the overlying massive conglomerate. The dyke No. 3 presents another case of irregularity; if it continued the course which it has in the river, it must have appeared in the upper workings of the Narbadá Company's colliery; but the coal there is totally unaffected by trap. Indeed, it is strange that where trap is so abundant none has been met with as yet in any of the pits, small though these are. There is no doubt, however, that this rock will yet prove troublesome in working the field. Where the coal-outcrop is exposed in the stream beyond the ridge north of the colliery, trap is in force close by, and must greatly affect the coal there.

There are three patches of overlying trap, apparently remnants of a once extensive spread. The detached hill half a mile to south-west of Mohpani is all trap; on the north and east this rock reaches down to the level of the plain; on the south-east Talchir rocks are found close to the base; and on the west side Barákar beds are well exposed to a height of some fifty feet. The trap near Kaklaur and Pipurea scarcely appears above the general level of the plain.

Connexion of the measures on the north and south.—Notwithstanding some slight differences in the details of the sections, and the very marked difference in the quality of the coal, there can be no doubt that the measures worked by the Sitariva Company in the vertical seams on the north are the same as the less troubled beds of the Narbadá Company on the south. There are three or four seams at the southern outcrop, and but two at the northern; and the associated beds do not exactly correspond in the two localities (there are some earthy beds above the coal on the north that are not found in the southern section); but these differences would come well within the known limits of variability of these deposits; and the position of the measures in the general section, with respect to the Mahadévas above and the Talchirs below, is precisely the same in both localities. There is, besides, the direct evidence of continuity; the ground is too covered to show quite an unbroken section, but

observations are close enough to leave no doubt on the point. The change in the quality of the coal is quite in accordance with the crushed condition of the strata. The coal from the vertical seams is friable and dusty, and burns without smoke, all the bituminous matter having apparently been extracted from it; it is consequently slow to ignite, but has strong heating power; the coal in its normal state at the Narbadá Company's mines has the usual composition of Indian coals; the subjoined analyses made by Mr. Tween exhibit the change:—

	Carbon.	Volatile.	Ash.
1. Narbadá Company's mines: top seam (river workings)	55·8	32·6	11·6
2. " " " 2 feet band of spurious cannel coal	33·1	24·6	42·3
3. " " main seam	50·4	39·0	10·6
4. " " "	51·9	33·4	14·7
5. Sitariva Company's mines: top seam	67·9	8·8	23·3
6. " " main seam	59·0	15·0	26·0
7. " " "	70·7	9·5	19·8

The Sitariva Company have sunk a shaft on the main vertical east-west seam to a depth of seventy feet, without any change, save a slight tendency to assume a northerly underlie. They have a shaft on the same coal about 200 yards off on the east side of the river, where the seam has already lowered to a dip of 65° to north-north-east. The Narbadá Company's collieries are in a corresponding position on the flat side of the flexure, at the south-east angle, where the strata are bending round the point of the anticlinal; and the galleries bring to sight many minor features of disturbance that could not be detected at the surface. Small as are the workings (the most extensive is about 400 feet long by 150 broad), they are on all sides stopped out against faults; it is true that none of these seem to have any great throw; but their frequency, and the crushing of the coal that attend them, is a serious obstacle and loss. It is to be expected that the coal that exists between the two present collieries is at least as troubled as that seen in the Narbadá Company's pits, probably more so.

Rough estimate of the field so far as proved.—Any estimate of the available coal-supply in this region must be affected by two considerations that do not present themselves in other Indian coal-fields: these are, the frequent high dip of the seam, and the fact that almost at all points thick overlying rocks rise into hills of considerable height close above the outcrop of the coal. Both these conditions will involve the necessity of deeper mining than has yet been attempted in India; in many places here they would restrict the mining to what can be obtained from shafts or galleries on or near the outcrop. Applying this rule to the known length of outcrop in the Mohpani neighbourhood, we may arrive at an approximate estimate of the coal from existing data: it may be said that there are about two miles of known outcrop, the coal being obscurely visible at the surface at several spots along the curved line between the two collieries, *but its thickness or its quality in that position has not been tried.* Assuming it to maintain a mean thickness of workable coal between the aggregates at the two collieries, say twenty-five feet, at the rate of 1,000 tons per foot of thickness per acre of seam, we should have 400,000 tons for every sixty-six feet down the seam along the whole length of two miles. As in many places the seam may be followed for many hundred feet, it is apparent that, without any very unwarrantable assumption, we may count upon a large supply of coal for many years to come.

Probable further extension of the field.—It is, as I have said, unfair to the field to pass an estimate upon it from the very insufficient information at present available; there is much hope that the coal will be found far beyond the limits taken in the estimate just given. I will now attempt to indicate the directions in which an extension may be sought. There are four considerations involved in a judgment: what may have been the original extent of the basin of deposition; how far the Barákar group ever extended in that basin; how far the coal may have been co-extensive with the group; and whether any portion of the group, and hence of the coal which is its uppermost member, had been broken up and destroyed before the Mahadéva deposits succeeded.

The first question affects the important point of the possible northern extension of the coal-measures beneath the plains: for several miles to east and west of the Sitariva no rock is seen to the north of the sedimentary series; and although the front here presented by these rocks is well up to the line of the general run of the metamorphic rocks bounding the basin at some distance to the north-north-east and west-south-west, there would be nothing forced in supposing that there was originally here a curve or bay in that boundary; the appearance here of rocks (the coal-measures) not seen elsewhere in corresponding positions might even suggest such a view. The questions will not, of course, be left to conjecture, but as it is desirable to proceed at first in the most promising direction, I would express my opinion that the measures do not extend northwards to any distance beyond the present known limits: such extreme disturbance of the strata as is seen in the Sitariva Company's collieries is not known to occur except close to the contact with the hard boundary rocks; a second reason is, that the massive coarse conglomerates of the Mahadéva series only occur close to the original rock-boundary, rapidly thinning out as they recede from that boundary; but here we find them in full force. In the figured section I have represented what I conceive to be the character of the section to the north of the present boundary with the superficial deposits.

The second and third considerations are much alike, and neither can be said to be altogether favorable; the Barákar coal is sometimes capricious in its development, as is corroborated by the beds here, the four seams of the Narbadá Company's pits being reduced to two at the Sitariva Company's mines; but certainly there is here no special ground for discouragement on this score. The occurrence of the formation itself is more open to doubt; it certainly is not co-extensive with the Mahadéva rocks; at many points along this boundary the latter are found resting upon the metamorphics, without any intervening representative of the older groups. This chance of failure is most likely to take effect in trials along the outer margin of the hills; but there is decided ground for hope that in a southerly direction, as far as they can be followed, the coal-measures will continue steady.

The fourth consideration is a very important one: if the Barákar group had been to any extent denuded before the deposition of the strata that now cover it, an indeterminate source of error would be introduced that might frustrate the most judicious calculations. This condition, so far as is known, is favorable: the Mahadévas have been subjected to the same disturbance as the coal measures, and wherever the section is visible, the top measures are found in place. There is even some evidence (though insufficient) to suggest a closer relation: thus, at the Sitariva mines the top beds of the measures are earthy, and so are the bottom Mahadévas; while in the southern section of the boundary in the river the rusty sandstone over the coal is not unlike the sandy base of the overlying Mahadéva conglomerate; this assimilation takes place within a thickness of a few feet, so does not seriously affect the position of the boundary. At the same time, at some points of this river section, there are appearances of the measures striking obliquely against the conglomerate; but this may well be due to one of the many small faults that trouble the strata in this locality. There are also some strong general considerations to suggest decided unconformability at this boundary, but they are too vague to be discussed here.

Extension eastwards.—It may be inferred from what has been said that my best hope for the field is in following the seams southwards; but there are other prospects worth investigation. A bore is now being sunk by my recommendation near Pukuhi, the most north-easterly point at which the measures come to the surface: the Barákar sandstone appears immediately beneath the red clays, both having a south-south-easterly dip of about 20°. The result of this trial will give the best indication for further explorations in the covered ground to north and east. The Narbadá Company's workings under the river in the top seam are beneath the conglomerate.

Westwards, on the flat ground.—As for the prospects in the low ground west of Mohpani there is really nothing to guide one, the rocks in that direction being indefinitely tossed about, denuded, and now covered by gravel and clay. The vertical seam worked by the Sitariva Company very soon passes under the deep alluvial clay; and there is no conjecturing what becomes of it: it can at least be said that there is no prospect whatever of the coal or its position being better in that direction. The Talchir rocks certainly reach for some distance to west of the Sitariva; they are seen close to the east base of the Mohpani trap-hill. On the west base of the same hill, the Barákar sandstone is well exposed, dipping under the trap; but it would seem that the upper portion containing the coal-measures has been removed either by the trap or previous to its outflow. Half a mile to west of this, there is another flat outcrop of sandstone, either Damúda or Talchir. In the stream half a mile east of Manigaon village, there is a small section of sandstone, clay and a lumpy limestone, that may be either Talchir or Mahadéva. The largest exposure of rock in this flat ground is

just south of Kaklaur, where sandstones have been extensively quarried in long trenches: they are fine-grained, pale, earthy flaggy sandstones with shaly partings; some are very regularly ripple-marked, and all have a steady dip of 15° to south; they seemed to me most like Upper Talchirs, but at one point next the trap south-east of Kaklaur, there is a thick, black, earthy rock, like a carbonaceous shale, altered by the igneous rock with which it is in contact. These few observations, which are all that I could discover in the flat ground between Mohpani and Khairí, where the metamorphic rocks appear in force, may serve to show how very precarious the search for coal must be in that area.

Southwards and westwards along base of ridge.—I would recommend, therefore, that every endeavour be at present directed to following the run of the coal-measures along the base of the ridge, where they must appear if they exist at all; and for some little distance at least, very positive directions can be given to guide the search. As has been already remarked, the coal in this field, wherever it is seen, occurs within a few yards of the base of the easily distinguished Mahadéva rocks. For a short distance, this character may be taken as a clue; but as the ridge is oblique to the boundary, and thus recedes from it westwards, the Mahadévas alter; sandstones and pale clays take the place of the coarse conglomerate at the base of the series; so that it becomes very difficult indeed to fix the boundary of the two formations where the sections are poor. The last place where this boundary is well seen is in the stream immediately west of Bainar village, where the conglomerate rests upon some sixty feet of sandstone, below which the section ceases. A trial shaft is now being sunk here, at my recommendation, by the Sitariva Company. For several miles to west of this, I only found one spot, on the east side of the recess south of Ríchai, where rock is visible below the conglomerate. South of Kaklaur I could not pronounce positively on the position of the rocks that are obscurely seen at the base of the ridge. For a mile from the base of the ridge in the Khairí stream, there is a fair section of the new bottom Mahadéva strata, pale greenish brown and mottled red clays with sandstones, having a variable dip. It is presumable that the outcrop of the coal-measures (if they have not thinned out and been overlapped) passes, between Kaklaur and the base of the range, towards the metamorphic rocks south-west of Khairí. The safe way to settle the point will be to follow the strike by shallow pits or borings westwards from Bainar.

Evidence as to southward extension.—An idea seems to have obtained that the coal does not exist beneath the Mahadéva rocks to the south, or at least that it is out of reach. This opinion appears to have been started by Mr. Blackwell, the mining engineer who selected the ground for the Narbadá Company: in a section drawn by him on the map of the ground, a great fault is placed along the boundary of the measures with the conglomerate. I can find no confirmation of such a view; and certainly the trap-dyke which Mr. Blackwell introduces along his fault has no existence. It is rather in that southerly direction that I hope the coal may be most favourably worked, as being probably steadier, less affected by faults and trap-dykes. The fact, however, remains to be proved. The Narbadá Company put down a bore (No. 2) to a depth of 256 feet on the flat ground of Mulpi village 1,100 feet from the boundary, in a south-easterly direction from bend of river, and south of the run of Mr. Blackwell's fault. The bore only passed through conglomerate and red clays; but taking the most favourable view of the case, supposing there to be no faulting whatever, and no thickening of the upper rocks,—the bore stopped just short of the measures. An average of several dips, taken in the conglomerate at the boundary, gives 15°; at 100 yards up the river it has flattened to 6°, which would reduce the mean to 13°5′, in which case the measures would be 266 feet deep at the bore in question. Another bore was put down to a considerable depth at the edge of the river below the bend; but this of course was a failure, being visibly below all the coal, every inch of the section being well exposed in the river close by. The best means of immediately testing the southern extension of the measures is from a shaft (No. 2) that was sunk to a depth of 143 feet close to the bend of the river on left bank. After passing through twenty-eight feet of surface gravel and forty-seven feet of conglomerate and red clay, the measures were reached, and coal was cut at the bottom. Unfortunately at this point the water made so fast that the work had to be stopped. The finding coal beneath the conglomerate does not finally settle the question of a great fault here, the pit being so near the boundary; and I was informed by Mr. Taylor, the very intelligent miner who had charge of the works at the time, that in the upper part of the shaft, and altogether in Mahadévas, the strata were cut by a fault having a steep southerly underlie; there was no means of gauging the amount of throw. The feature is now concealed by the casing of the shaft. Where small faults are so frequent, as in the mines close by, there is really nothing especially discouraging in finding one here; it is probably no greater than those

already known; and it may be hoped that the measures will rapidly assume a steady low dip, conformable to that observed in the overlying Mahadévas. I have urgently recommended that the seam at the foot of this shaft be followed out southwards, and any fault-ground be thoroughly explored. Machinery is being put up to drain the shaft. The difficulty of unwatering mines in this position is one that must be anticipated: at the base of a high ridge, having a trough-shaped arrangement of the strata, a heavy discharge of water seems inevitable; it is possible that the excessive discharge in this particular shaft may be increased by the proximity of a deep pool in the river just above.

The same indications applicable to other localities.—The indications I have here given to guide in the exploration of the Mohpani field ought to be of service in the search for other fields along the margin of the basin: thus, in the gorge south of Fattehpúr, near Bunkheri railway station, the conglomerate laps round the west end of the ridge of metamorphic rocks, the east end of which is at Khairí; a short way up, the river bifurcates; and just above this there is a small patch of the Talchir boulder bed, surrounded by the Mahadéva conglomerate; it is possible, though not very likely, as this is the lowest level, that outcrops of the Damúdas might be found in the neighbourhood; and similarly elsewhere. It is to settle such points that the detailed survey is so much needed; meanwhile the indications I have given may be of service to independent explorers.

I cannot conclude this report without an expression of regret at the obstructions that are being raised to the development of the Mohpani coal-field. Several years ago mining was commenced with the intention of having the works well opened so as to be in a state to turn out a large supply of coal by the time the railway should be finished; all prospects of profit being necessarily dependent upon that event. The completion of the railway was repeatedly postponed year after year, the mining establishment and plant being necessarily maintained all the time. And now that the main line is opened, and there is a prospect of a return for the outlay on the mines, numerous delays and objections are made to the construction of the short branch line, without which the mines cannot be worked. Questions are still raised as to the relative quality of the coal; upon which point all reasonable doubt has been long since settled; for it may be safely asserted that a large portion of the coal now consumed over the East Indian Railway line is no better than the Mohpani coal. For the Jabalpúr line, and even so far as Naini junction, the Mohpani coal could undersell the Bengal coal, and a considerable saving be made in the railway expenditure. Questions of separate accounts and the desire to show profits on one side or other ought not to be allowed to lead to the public being heavy losers.

1*st May* 1870.

Note on the lead-ore at Slimanábád, Jabalpúr District, Central Provinces,—by Theo. W. H. Hughes, F. G. S., Assoc. Roy. School of Mines, Geological Survey of India.

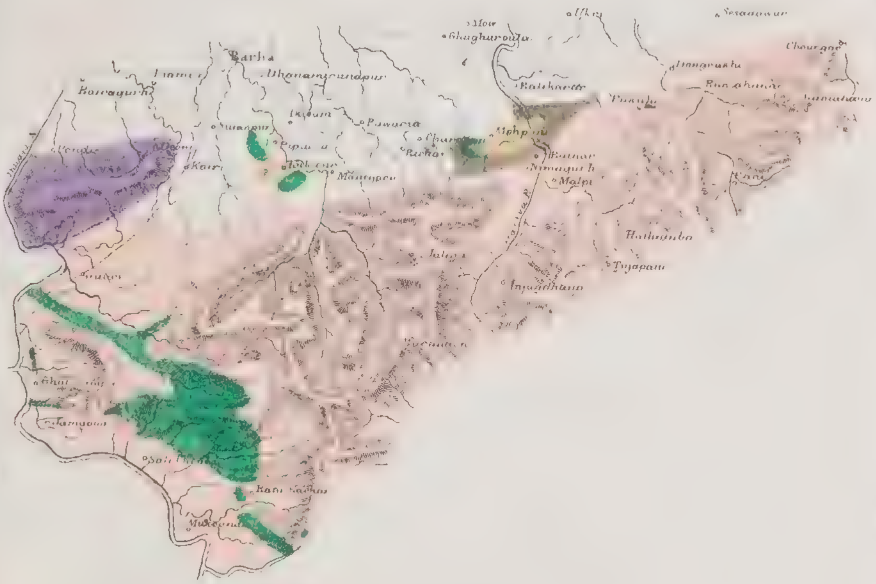
In April last, Mr. Olpherts, Resident Engineer on the Jabalpúr line of railway, announced in a letter addressed to Mr. W. B. Jones, the Deputy Commissioner of Jabalpúr, that he had discovered indications of copper ore about three miles north of the Slimanábád railway station, and expressed a hope that the matter might be further investigated.

Discovery of copper and lead.—Mr Olpherts' attention was first drawn to this subject by noticing some copper stains on the foundation rock of one of the piers for a railway bridge. After making known this discovery, he noted the strike of what he considered the *lode*, and pursuing his researches to the west of the line of railway hit upon another locality—about two miles from the railway station of Slimanábád, and a little off the main road leading to the town, which yielded an ore of lead (galena).

I visited this latter spot accompanied by my colleague, Mr. Fedden.

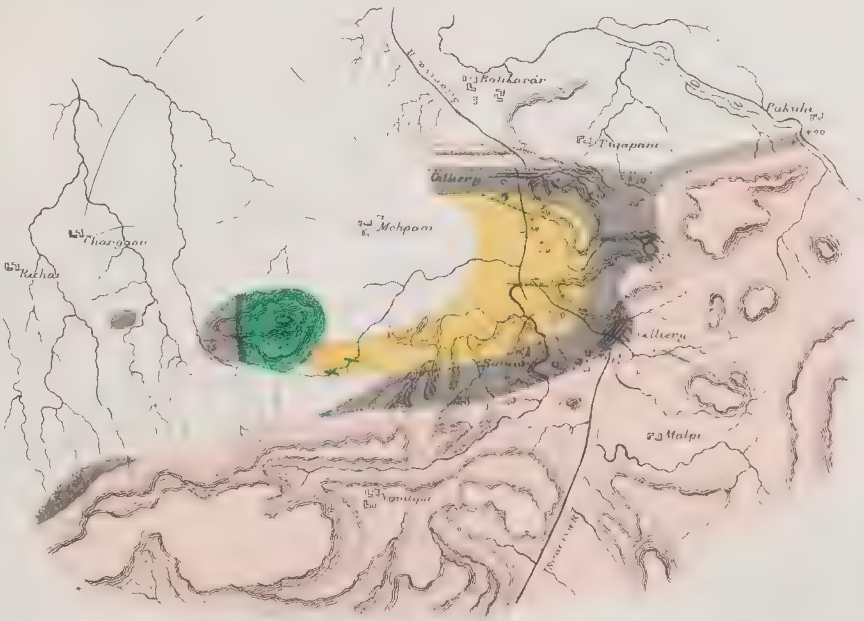
There was very little to be seen, merely a small ridge of quartzite rock, about eight feet in height, forty feet or so in breadth, and a few yards in length, throughout a narrow band of which galena (Pb. S.) was sparsedly distributed, with here and there a little copper pyrites.

Stratigraphical relation of ridge.—A very important point to determine was the stratigraphical relation of this ridge. It did not strike either my colleague or myself that it was a *lode*, but rather a component bed of the geological series which occurs at Slimanábád. The ridge is made up of quartzite, and not of vein quartz; and though many of the hand



MOHPANI AND NEIGHBOURHOOD

Scale 4 Miles = 1 Inch



MOHPANI COAL FIELD

Scale 1 Mile = 1 Inch

Mahadeva — Coal Measures — Talchir — Metamorphic — Trap — Dips, Shafts o Boring +

The ground covered by superficial deposits is uncoloured

specimens which I brought away, and others that were in Mr. Olpherts' possession, might possibly convey the idea that the ore existed in a lode, such a misapprehension would arise only from the examination of small pieces of the matrix.

The dip of the bedding is rather obscure, but its direction appears to be 45° south of east. There are planes of jointing striking 20° north of west and inclined at an angle of 75° in a southerly direction.

The strike of the beds is north-east—south-west; so that if this line were followed up, we should most probably find a connection between the two localities where lead and copper ore have been respectively found.

Description of ore.—The ore of lead is galena, a combination of lead and sulphur with a certain proportion of silver. An assay made by Mr. Tween in the Office of the Geological Survey proved the ore to contain 19 oz. 12 dwts. of silver to the ton of lead. The ore of copper is pyrites, which is usually a combination of copper, iron, and sulphur.

At the locality where Mr. Olpherts first noticed traces of copper, the ore is principally malachite, but there appears also to be some dioxide of copper (Cu_2O). From a conversation which I had with Mr. Olpherts, I gathered that the ore was only sparingly distributed throughout the matrix.

Origin of ore in the rock.—The lead occurring in a bed, and not in a lode, it is most probable that it was an original constituent of the rock in which it is now found; and that whilst the rock was undergoing metamorphism the lead became segregated

Economic value.—In order to form a reliable estimate of the probable richness of this find, I had hoped that a fair amount of clean cut surface would have been exposed for examination, but this was not the case, as Mr. Olpherts, who had the management of the prospecting operations, had not had time to open out enough of the bed.

If the indications, however, of lead at the surface may be taken as a fair criterion of the richness of this quartzite, then I would at once condemn the whole, the proportion of ore to matrix being far too small to make the working of this bed a desirable speculation. It may also be stated that lead ores occurring in beds or nests are usually poor in silver. But it would be premature to pass a final condemnation until further investigations had taken place, and although, as I said above, the indications are unpromising, I would yet recommend that a sum of 2 to 300 rupees should be placed at Mr. Olpherts' command in order that he might carry out to a more satisfactory conclusion the researches which he has initiated.

Incidentally, I may mention that Mr. Olpherts possesses an extensive collection of the various iron ores of the country. Many of these are very rich and occur in great abundance near to and around Slimanábád.

June 1*st*, 1870.

NOTE ON THE OCCURRENCE OF COAL EAST OF CHHATISGARH IN THE COUNTRY BETWEEN BILASPÚR AND RÁNCHI, by W. T. BLANFORD, F. G. S., Depy. Supdt., Geological Survey of India.

The coal bearing (Damúda) beds of Korba extend for about forty miles to the eastward as far as Rábkúb, in Udipúr (Oodeypore). They also extend far to the south-east towards Gángpúr, and to the northwards towards Sirgúja, and in all probability are continuous or nearly so with the deposits of the same nature known to occur in those districts.

Main Pat with the neighbouring hills and all the country on the road from Main Pat through Chándargarh and Jashpúr to Ránchi consist of metamorphic rocks with the exception of a cap of trap and laterite on Main Pat.

The lateness of the season* prevented my searching to any extent for coal seams, indications of the existence of which were afforded by the occurrence of fragments of coal in the rivers, especially in the Mánd. I found a few seams near Chitra, twelve miles west of Rábkúb and nearly thirty east of Korba. Two or three are seen in the Mánd about three to four miles east-north-east of Chitra, but they are only from a foot to eighteen inches in thickness. In a small stream, the Kopa Naddi, which runs south of Chitra, one seam, about three feet in

* After the end of April I had still 250 miles to march to Hazáríbágh.

thickness, is seen near the village of Tendúmúri, more than a mile south-west of Chitra. It is nearly horizontal, having a very low irregular dip to the west or south-west. Part consists of fair coal, the remainder is shaly.

The only seam examined from which it is possible that a useful supply of fuel might be obtained is exposed in the same stream rather nearer to Chitra, being about a mile from that village, close to the boundary of the village of Tendúmúri. It is very badly seen, but appears to be of considerable thickness, perhaps twenty feet. The upper portion is so much decomposed that no trustworthy estimate could be formed of the quality without digging into the seam: the lower portion appeared to be fair in places. The dip is about 15° to north-north-west.

The villagers, as usual, would give no information, so that I could only trace out the coal seams by the laborious process of searching the beds of the streams, and from want of time I was unable to ascertain whence the greater portion of the fragments seen in the Mánd were derived; but when passing through Ránchi, Lieutenant Sale, in charge of the Chota Nágpúr Topographical Survey Party, told me he had found a seam of coal about four miles north-west of Rábkúb in a small stream running into the Mánd, and it is probable that this may be the source of the blocks I saw in the river bed.

I should add that several coal localities have been lately found by the officers of the Topographical Survey and recorded in their maps. They are all north of Korba and Udipúr.

When passing through Jashpúr, the Rajah told me that coal has been found in his territory in the Khurea country, twenty-four miles north-west of Jashpúrnagar. This would be about 100 miles, or rather more, west by south of Ránchi.

Calcutta, 31st May 1870.

NOTE ON PETROLEUM IN BURMAH, &C., by WILLIAM THEOBALD, ESQ., Geological Survey of India.

Two very distinct sorts of earth-oil are met with in the countries lying to the eastward of the Bay of Bengal, *viz.*, the limpid oil of Arakan and the viscid oil of Burmah, which last is commercially known as the Rangoon oil from its port of shipment, though really obtained at the Yenán-khyoung and other wells in Upper Burmah. The limpid oil of Arakan varies in tint from pale yellow to deep sherry brown, with a peculiar opaline tinge, something like that produced in alchoholic fluids by the presence of fusil oil in excess. The Rangoon oil, on the other hand, is of very uniform color, a peculiar yellowish green and of tarry consistency.

I may here remark that the only other Indian oil I am acquainted with is that produced in the salt range in the Punjáb. This oil is of a consistency almost intermediate between the Arakan and Burmah oil, and differs in tint from both, being brown, devoid of the peculiar greenish hue of the Rangoon oil, and of a decidedly reddish color by transmitted light.* The wells producing the limpid oil are situated near Kyoukphoo, Ramree, and the neighbourhood, and are all confined to the western side of the Arakan range, and none of them occur at any great distance from the coast, whilst the viscid oil of commerce is similarly confined to the eastern side of the same range, occurring most plentifully in Upper Burmah, but met with here and there in very sparing quantity as low down as the parallel of Myanoung.

Of the mode of occurrence of the Arakan oil and of the rocks with which it is associated little is known. The wells are mostly shallow, almost superficial, and would seem only to yield sufficient oil for local use, though their productive capacity has probably never been fairly tested.

The Burmese oil is worked much more energetically, though the geological relations of the oil are little better known than in Arakan. Some of the Yenán-khyoung wells are, I am informed, sunk to a depth of 100 or 150 cubits, first through a little surface clay and then in soft sandstone. The age of these beds is not precisely known, but analogy would point to the nummulitic formation as being the source of these oils. In the Punjáb, the oil rises through contorted beds of nummulitic limestone, and is there in all probability derived from thick beds of carbonaceous shale with lignite, which are associated with and underlie the nummulitic group. As the nummulitic group is largely developed in Burmah, we may, in default of any precise information on the subject, refer in like manner the Burmese oils to the same group.

* Dr. Oldham has drawn my attention to a remark of Mr. Wynne, that the oil obtained near Rawul Pindi is green, when it issues to the surface. The distinction, therefore, drawn by me between the color of the Punjáb and Rangoon oils would seem to depend mainly on the relative length of time either has been kept, and does not seem, as at first inferred, to originate in any essential difference of composition.—W. T.

In the province of Pegu no nummulitic rocks occur at the surface east of the Irawadi, which entire region is occupied by a newer group of miocene age or younger, and no petroleum well is authentically known within this area. A little below Namián there is a tradition of petroleum having once been known to occur, but I visited the spot and could detect nothing to countenance the rumour in the appearance of the sandstone or any of the neighbouring rocks. The occurrence of oil, therefore, east of the Irawadi in Pegu must be held to be an open question.

West of the river, the only situation where petroleum is known to occur which I have as yet had an opportunity of visiting, is the newly discovered locality at Padoukbeen west of Thaietmio. The well was here sunk to a depth of about twenty feet in soft argillaceous sandstone, rather tender and incoherent and of a dark bluish color, drying paler. The beds in the neighbourhood are shales and sandstones of the miocene series, dipping at low angles and very little disturbed, and not in the slightest degree altered. The oil seems to have been discovered by its saturating the soft sandstone where cut by a small stream in the bed of which the well is sunk, the top being a little way up the bank, but the well being carried below the level of the bed of the stream. Whether the well continues to yield, I cannot say. At my second visit it was abandoned and dry, but I hear it has again been worked. The oil from this spot is precisely similar in every respect to the commercial or Yenán-khyoung oil, and is regarded as equal to it in value by the natives.

There is no indication at this spot of any fault, and the chances of improving the supply by a deep boring are hardly greater than of failure, as there is so little to guide the judgment as to the source of the oil, and as these beds are, I believe, high in the series to which they belong, a very thick set of unproductive beds would have to be passed through, unless the bore struck a seam containing sufficient oil to constitute a flowing well, the presence of which is by no means assured by the insignificant surface indications.

Note on the Petroleum Locality of Sudkal, near Futtijung, west of Rawul Pindi, Punjáb, by A. B. Wynne, F. G. S., Geological Survey of India.

The petroleum at this place occurs (as usual in the Punjáb, *vide* Geological Reports, Asiatic Society, &c.,) in the nummulitic tertiary rocks. Just near the petroleum pits, as well as to the north and south, fossils occur, orbitolites being by far the most numerous, but bivalve shells in a fragmentary state, teeth of sharks, and large bones are also to be found.

The pits, only one of which is of any depth, are situated in a small open space a couple of hundred yards wide from north to south, covered with superficial debris, and bounded in these directions by rocky ridges of slight elevation. To the east and west are the sources of some of the numerous steep ravines which intersect the country everywhere.

The tertiary rocks on both of these ridges are much contorted along narrow axes, but still possess considerable regularity of strike in a direction about 10° north of east and south of west. They dip at high angles, varying from vertical to 50° or 60° generally west of north and east of south, but lower angles and horizontal beds may also be observed forming parts of curves in the same neighbourhood.

The rocks consist mainly of gray grits and sandstones, with some bands of gray fossiliferous limestone interstratified with thick zones of red shale.

In the immediate vicinity of the pits the strike of the rocks changes to about north-east; they dip at very high angles to the north-west and seem to run against a mass of red shales within a few yards of the principal sinking, being perhaps faulted, but the relations are almost entirely concealed by the covering of superficial debris.

To the southward of the present works within a few feet dark brown shales and sandstones impregnated with petroleum are exposed by an open 'drift' or 'stope' (cut apparently to seek the most productive band), and these as well as a band of limestone in places saturated with the oil may be traced for a few yards north-eastwards, where a quantity of the oil seems to have exuded from the rocks and mingled with the surface soil.

Owing to the abandoned state of the works at present and the insecure gear at the pit's mouth, it was not found practicable to descend, but as the pit is only twenty or thirty feet in depth, the oil could be seen trickling from the highly inclined strata forming the sides, and which dip at the upper part of the pit north-west at 70°. A 'dhol,' lowered quietly and drawn up as rapidly as possible to avoid loss by reason of its leaky condition, contained

about seven or eight vertical inches of the oil floating upon clear water, this being rather less than the probable depth of that in the pit, which had been accumulating for three or four months.

It was stated by a native in charge of the place that the oil ran slowly and coagulated in the cold weather, in consequence of which the works had been temporarily stopped, and that when in operation about one maund of oil daily could be obtained. The colour of that taken from the pit was green, but some found in a neighbouring shed was of a dark brown tinge, and burned readily with dense black smoke.

It is understood that the mineral oil procured from here is to be used in lighting the station of Rawul Pindi with gas. A 'gas house' was seen in course of construction there, and large gas mains lie along some of the roads, so that the question of supply becomes of importance: the quantity reported to be obtainable seems so far from encouraging that I doubt whether some larger prospect must not have existed before an expenditure upon gas pipes, &c., was sanctioned.

The locality where the oil occurs is evidently of but limited extent near the village of Súdkal, and it would appear necessary, in order to develop its resources, to open much more extensively, across the run of the beds, trenches cut downwards to the rocks, which are now so much concealed just near the pits. Even if this was done and other pits sunk, there is no reason to suppose any of them would be more productive than the present shaft, and so far as can be judged from what is visible there is not room for many.

As to the possibility of an increased quantity of the oil being obtained by deepening the existing shaft, it can only be said that as the beds are nearly vertical with some underlie north-westward, if these relations are preserved, the pit in depth ought to pass through the beds at present yielding the oil and to enter those seen at the surface in the drift south of the pit, where it may be presumed the prospect of finding the oil in sufficient quantity was less favourable, or the shaft would have been sunk there. As the bedding of the rocks is much disturbed their continuing to lie in the same position for any distance cannot be calculated upon, but it seems likely that (if it has not already been done) the shaft might with some advantage be carried down to intersect the oil-bearing rocks south of the pit.

To sum up: from what is now to be seen at this petroleum locality, it would be advisable to extend the search further before building hopes upon the place as a source of supply for lighting Rawul Pindi, and the quantity said by the man in charge to have been obtained from the present sinking would hardly warrant expectation that sufficiently large results would be obtained by opening other shafts in the same neighbourhood.

ON THE OCCURRENCE OF ARGENTIFEROUS GALENA AND COPPER IN THE DISTRICT OF MÂNBHÚM, SOUTH-WEST FRONTIER OF BENGAL,—by V. BALL, Esq., B. A., Geological Survey of India.

Although the greater portion of the district of Mânbhúm consists of metamorphic and sub-metamorphic rocks*, both, but especially the latter, likely to contain ores of the useful metals, hitherto no discoveries of the existence of any appear to have been recorded.

The occurrence of gold in the streams of Mânbhúm and the adjoining districts has, however, long been known. Its mode of occurrence has already been described in these pages†.

During my geological examination of Mânbhúm, the discovery of galena or lead ore was made in the following manner:—When at Dadka, a large village forty-five miles south-south-east of Púrúlia, which is the sudder station of Mânbhúm, the *Ghatwal* brought to me a small piece of galena which had been given to him a few years before by some *Kumars*. He did not know what it was, but used some of it instead of *Surma* or antimony for the purpose of anointing the eyes of his female relatives.

By enquiry from the *Kumars* of the neighbourhood, I was, after several failures, at length enabled to trace the source from whence the galena had been obtained. The lode, for it proved to be such, had been struck some years previously by some *Kumars* who were searching for iron on the side of a hill formed of mica schist, in which there are a number of

* Slates, quartzites, schists, &c. † Records, 1869, II.

veins or small lodes filled with brown hæmatite. This hill is close to a *dih* called Jani-jour, where there is an outlying house of the village of Dekia, which lies about a mile east from Dadka.

I could not ascertain that the *Kumars* had met with galena in any other part of the neighbourhood, though excavations for iron were plentiful.

Having found traces of galena on the surface, I proceeded to excavate, and soon obtained a number of fine specimens of the ore. It occurred quite independently of the bedding of the schists, sometimes in lenticular masses five or six inches long surrounded by quartz, and sometimes in a gangue principally composed of brown hæmatite and quartz; these appearances justify the conclusion that this is a case of a true lode. Owing to the excessively jungly and broken condition of the ground, I was unable, during the period of my brief visit, to trace the lode for any distance, and for the same reason I was unable to ascertain its exact width. Although, therefore, much remains to be ascertained regarding it, still, so far as it has been examined, the indications may be affirmed to be promising. All who have given the least attention to the history of mining are aware of the capricious character of lodes, and of the impossibility of forming even an approximately correct opinion as to the value of any particular one—which is not laid open by a natural section—until some outlay for excavation has been incurred.

In addition to the fact of the existence in any part of this country of such an ore as galena—supposing it to be in quantity—there are many collateral questions and conditions to be considered and ascertained before the commercial value can be properly estimated; of these the most important are the presence or absence of other valuable ores or metals in association with the principal, the abundance and quality of labour and fuel to be obtained on the spot, the means of carriage with the distance of the nearest mart, and, perhaps, not of least importance, the healthiness of the locality.

With regard to the first question, the assay of some of my specimens by Mr. Tween has proved the presence of silver in the unusually large proportion of 119 oz. 4 dwts. 16 grs. per ton of lead*. The assays of most other Indian galenas have given a much smaller amount than this. In Europe, from 35 to 40 oz. per ton is considered quite above the average yield, and argentiferous galena containing very much smaller amounts is frequently worked for silver with profit.

Mr. Tween has also ascertained the presence of antimony in combination with the lead.

Regarding the amount of coolie labour to be obtained, I have no hesitation in saying that it would be abundant. Such was found to be the case in Singhbhúm, when the Copper Company was at work there.

Of the fuel, it is not easy to speak with so much confidence: undoubtedly there is a very considerable amount to be had close by, as the locality is almost in the centre of the heaviest tree jungle in Mânbhúm; but all experience goes to show that such a source of supply is very precarious and uncertain. Possibly it might be found more economical to transmit the ore—should it ever be worked—to the neighbourhood of coal, rather than to attempt smelting on the spot.

The means of carriage are indifferent, or rather bad. Dadka is connected with Púrúlia by a partially finished road, without bridges, which was commenced during the famine. From Púrúlia to the Barákar Railway Station there is a road which has for many years been in the hands of the Public Works Department, but is still far from finished. The distance by these roads is about ninety miles. From Dadka to Midnapore *viâ* Silda, the distance over bad roads would be about seventy miles. From Midnapore the ore or metal might be sent by canal to Calcutta.

The climate is not generally considered healthy for Europeans; still there are many worse places in the district. Doubtless the removal of the heavy jungle would ultimately produce a beneficial effect.

The nearest locality to this at which lead has been discovered is at Hisato in Chota Nagpúr. The antimonial galena from that locality has been described by Mr. Piddington.† From the first specimens sent to him by Major Ouseley he obtained silver in the proportion of 70 oz. per ton of ore; but other specimens subsequently received did not contain a trace of silver.

* This proportion may possibly not be constant throughout.

† Jour., Asiat. Soc., Bengal, XI, p. 892; XII, p. 736; XV, p. 64.

COPPER ORES.

Copper ores have been discovered in two localities in Mánbhúm. The principal is situated on the crushed and faulted junction of the metamorphic and sub-metamorphic rocks about one mile north-east of the village of Poordah, Pergunnah Mánbazaar, or about thirty miles from Púrúlia.

The rock in which the ore occurs is a coarse mica schist, which is traversed by numerous veins of quartz. Whatever the amount or quality of the original ore may have been which existed near the surface, it has nearly all been removed by natives, slight stains of the carbonates of copper on the schist and quartz debris alone remaining to indicate the object for which the numerous excavations which occur along the outcrop have been made.

These ancient excavations at the time of my visit were filled up, some with water, others with debris, which circumstance, coupled with the fact of the ore having been removed, rendered it difficult to form a decided opinion as to the precise nature of the deposit. Subsequent examination of the numerous and often well-exposed copper ore deposits of Singhbhúm*, which appear to be of mixed character (generally the ore occurs disseminated through regular beds of schist; but departing from this rule, it occasionally occurs in true lodes), has induced me to believe that these ill-seen Mânbhúm ores also occur in a two-fold manner. It is possible that the copper-bearing beds of Mânbhúm may belong to the same Geological Zone as those of Singhbhúm; but there are arguments against, as well as for, this view. The whole question must be treated in greater detail than is now possible.

The second locality at which copper occurs is near the village of Kulianpúr, or about thirty-two miles due west of that just noticed. It is on a small hill formed of schists and quartzites, which in one place are stained and encrusted with the carbonates of copper. There is an ancient excavation on the south flank of the hill. So far as it is possible to judge, the deposit seems similar to No. 1. It is not improbable that the ore may be found further westwards, but I did not succeed in obtaining any trace of it in the section exposed in the Subanrika river. There is a small quantity of slag at the bottom of the hill, which indicates that the ore which was found here was smelted on the spot.

The small indications of ore to be seen at the two localities mentioned above are certainly not sufficient to justify any expenditure for excavating, more especially as the attempts to work the similar, but vastly more extensive copper deposits of Singhbhúm, have not hitherto proved to be remunerative speculations.

Various rumours of the occurrence of ores of tin and copper in different parts of Mânbhúm have from time to time been promulgated; but the supposed ores of the more valuable metals have generally proved to be either some form of iron ore, the green mineral epidote, or a bronze-coloured mica.

30*th June* 1870.

DONATIONS TO MUSEUM.

April 2*nd.*—Specimens of salt from the Sambur Lake. R. M. ADAM, ESQ.

,, 25*th.*—Specimen of petrified grass (rushes) from Java. MRS. BANZIGER.

May 1*st.*—Two earthen pots from the Andamans and Nicobar Islands, a few stone implements, and fragments of pottery from the Andamans.
FERD. STOLICZKA, PH. D.

,, 1*st.*—A cup carved in serpentine from Skardo, Little Tibet. Ditto.

,, 2*nd.*—Twenty-one ornamental (carved and moulded) bricks from Kishnagurh.
MRS. WOOD.

June 13*th.*—A perfect crystal of oxide of iron, pseudomorphic of iron pyrites, from the foot of Sinawur hill, at head of the Suddoom valley.
CAPTAIN T. T. CARTER, R. E.

,, 29*th.*—A complete series of tools, used in South Staffordshire for sinking colliery pits and for working coal and ironstone. S. MINTON, Esq., DUDLEY.

* A description of these will appear in a future number in the map accompanying which the position of the lead ore will be indicated.

In addition to the above, we have received many specimens of various kinds for assay, or examination, among which some of the more important were of iron ores from various localities.

The results of a recent search in the neighbourhood of Hazáríbágh yielded to Dr. Coates and Mr. Donaldson a considerable variety of ores, the principal of which were from the Káranpúrá coal-field and its vicinity, examined sometime since, but not published from want of a correct map. The following numbers show the percentage of metallic iron contained in each. Of course this is the full percentage, and this proportion would not be obtained in manufacture. As the details of these researches will be given elsewhere, we only give the localities and percentages here :—

Belhargadhá	30·6	per cent. of iron.
Chépojúgra in the Káranpúrá valley ...	56·8	,,
Muraí Kalan	16·4	,,
Gondalpúra	37·3	,,
Áráhárá stream	42·12	,,
Áráhárá village	11·2	,,
Seam 12 feet thick in Damúda	25·6	,,
Mándú	33·8	,,

A specimen, found loose, to the north-west of Hazáríbágh yielded 68·7 per cent. With the exception of this, which is magnetite, and of the Belhargadhá specimen, all the others are varieties of clay-ironstone.

From the Wún District, East Berar, the Deputy Commissioner forwarded several ores for assay. Some of these were fine rich brown hæmatite traversed by crystalline veins of the pure mineral; these varieties were assayed, yielding, respectively, 60·4, 56·3, and 44·0 per cent. of iron. If with these we take the percentage of the pure limonite, we will have—

$$\begin{matrix} 63{\cdot}2 \\ 60{\cdot}4 \\ 56{\cdot}3 \\ 44{\cdot}0 \end{matrix} = \frac{224}{4}, \text{ or an average yield of 56 per cent. of}$$

metallic iron. There are distinct traces of phosphorus. These specimens were from veins of segregation traversing the beds; but some of the beds themselves are rich and useful ores yielding 48·0 and 45·8 per cent. of iron.

In the immediate neighbourhood of these ores heaps of old slag are scattered over the ground. These slags, the result generally of very crude and inefficient methods of smelting, often contain a very large dose of iron, and it was interesting to examine them. Two specimens were assayed; and one yielded 38·0, the other 34·8 per cent. of iron—an amount which would be ample to pay for re-smelting these slags in conjunction with other ores.

In the Yenak hills, which occur west of the village of that name, near the river Paínganga, in the southern part of the Wún District, East Berar, Mr. Hughes and Mr. Fedden, during their recent examination of the country, traced over an extent of some five to six miles in length two thick beds of conglomerate (nowhere less than nine feet) containing a large proportion of rolled lumps of a very rich hæmatite. This on assay yielded no less than 68·5 per cent. of iron with a trace of phosphorus—no manganese.

All these are rich and valuable ores of iron and occur in large abundance. The noted hill from which much of the ore smelted by the natives in North-Eastern Chanda is derived, the Lohara hill, near Bissanpúrí, is one mass of iron-ore of a couple of miles in length. A specimen brought by Mr. W. T. Blanford proved to be nearly pure specular iron with a proportion of magnetic iron, and yielded to assay 70 per cent. of metallic iron!

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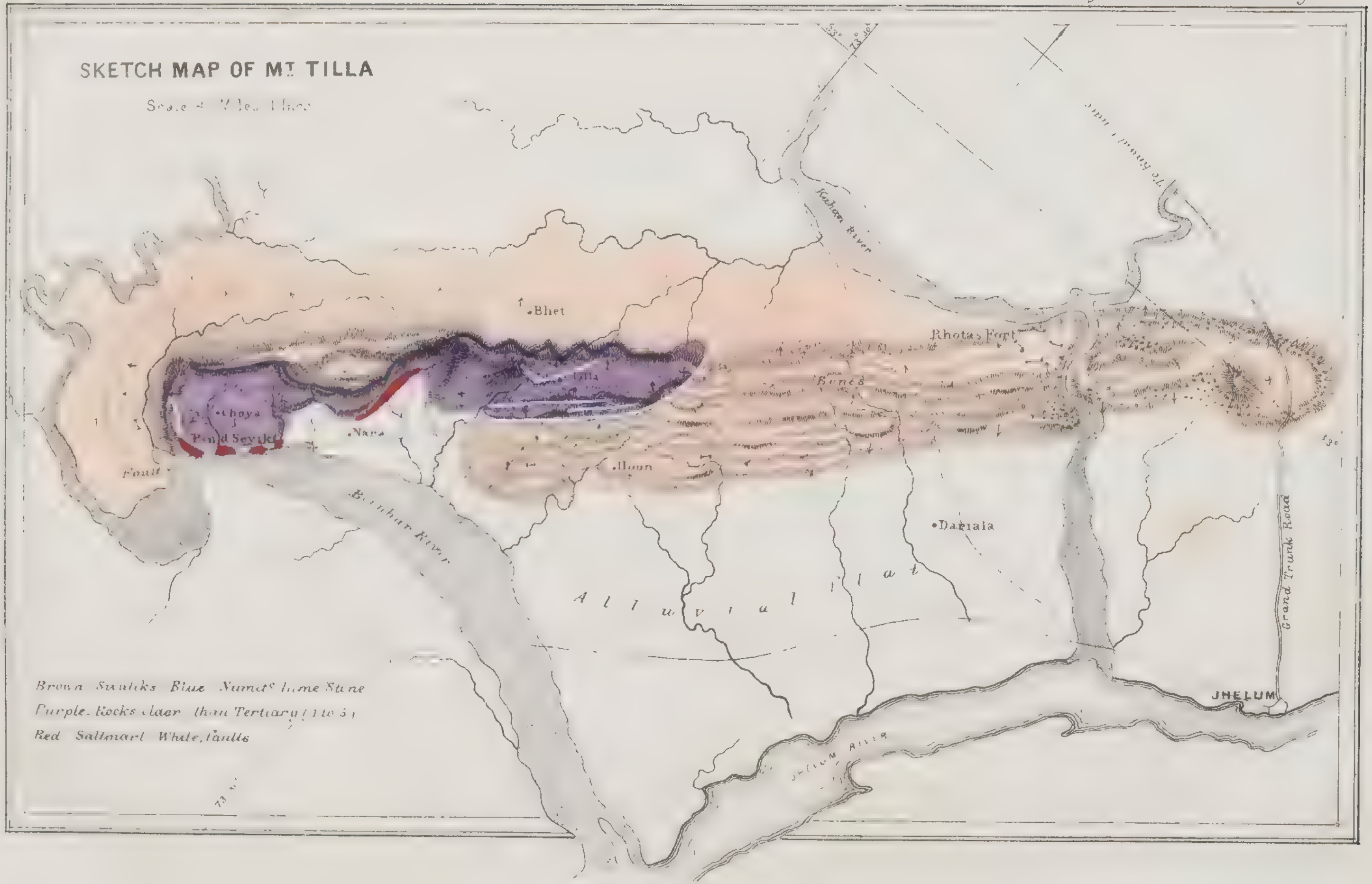

SKETCH MAP OF Mt TILLA
Brown Sivaliks Blue Numms Lime Stone
Purple Rocks older than Tertiary (1 to 5)
Red Saltmarl White faults
Bhet
Rhotas Fort
Choya
Pind Sevyki
Nara
Boon
Fouit
Bunhar River
Kahan River
Daniala
Alluvial flat
Jhelum River
JHELUM
Grand Trunk Road

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 4.] 1870 [November.

ON THE GEOLOGY OF MOUNT TILLA IN THE PUNJAB, by A. B. WYNNE, F. G. S., Geological Survey of India.

The fine hill which forms the subject of this brief memoir rises between the eastern termination of the Salt Range proper and the outworks of the Western Himalaya where the river Jhelum emerges from them to traverse the vast plain of the *Five Rivers* which united in the Lower Indus (or Sind) reach the sea near Kurrachi.

It is one of three or four minor ranges, all of which form links more or less between the Himalaya and the Salt Range. Of these the parallel chain of the Bukrala Hills to the north seems to form the most continuous connexion; but Mount Tilla exceeds them all in height, reaching an elevation of 3,242 feet above the sea. It runs generally north-easterly by east, commences abruptly at its western end, and continues thence lofty for about ten miles, when it sinks rather suddenly into high ravine ground, with elevations of over 1,200 and 1,300 feet, for about twelve miles further, past the extensive ruined fortress of Rhotas. It terminates in low rounded hills a few miles beyond this point, projecting into the commencement of the alluvial plains of the river Jhelum. It is widest where most lofty, having a base of three miles, but the extension of the range to the eastward is on an average not less than two and half miles in width.

Neither the Mount Tilla range nor that of Bukrala to the north appear to have any strong relation to the drainage depressions of the country in their immediate vicinity, both of these ridges and the valley between being crossed by the usually dry or nearly dry courses of streams, occasionally powerful, as indicated by the depths of their gorges and great width of their sandy beds when the currents become slack. With the Jhelum, however, ordinary relations seem to exist after it has left the Himalaya; the direction of the Tilla range coinciding more or less with that of the river, and the ground falling generally towards the latter—except where one of the other chains or groups of hills intervenes—on the southern side of the ridge.

The existence of Mount Tilla as a striking feature of the country—that of Chambal to the south, of the Bukrala range to the north, and indeed perhaps of the whole Salt Range itself—is, through denudation, directly due to huge dislocation of the stratified rocks, placing certain of the beds of greater or less strength in abnormal contact with others possessing different degrees of resistance to disintegrating forces. The chief line of dislocation affecting Mount Tilla passes along its southern base, obliquely separating the lofty portion from the lower extension to the east, and is perhaps continuous westward, though concealed, to the great fracture lying in the bed of the Boonhar river, which separates the adjacent portion of the Chambal range from the western termination of Tilla, completely discordant dips occurring on each side of the here constricted channel.

As results of the forces, or of similar forces to those, which caused this and other fractures, the whole strata of the country have been subjected to violent contortion, one of the finest curves being the interrupted anticlinal formed by the strata of Mount Tilla itself and traceable round its western end nearly to the line of dislocation occupying the lower gorge of the Boonhar.*

* On one of the early days of last April a somewhat singular occurrence was observed from the higher parts of Mount Tilla. The day was warm and bright, and a very strong breeze blowing, so much so that traversing

The denuding agencies acting strongly upon the varying consistencies of the rocks of this country have not only produced dominant features coinciding with the principal contortions and dislocations, but in much more minute detail caused their stratification so to govern the forms of the ground that the minor contortions in many cases become plainly visible in the ornamental hill-shading upon the very excellent one-inch (to the mile) maps produced by the Topographical Survey. This is much most prominent in the soft tertiary rocks which form so much of the surrounding country stretching far into the outer Himalaya; and it is partly a consequence of the steepness of the angles at which the strata are inclined in various directions. A wide belt of these tertiary rocks is known to border much of the Western Himalaya. Those which underlie them in the hills between the Ganges and Ravee have also been ascertained and described by Mr. Medlicott in one of the Survey Memoirs. Westwards or north-westwards from the Ravee river this succession has not yet been clearly worked out, but what is known renders it probable that the geology of this part of the hills will be found a continuation of that to the south-east. The very interesting Salt Range also exposes rocks older than this tertiary series which have not hitherto been identified with the infra-tertiary rocks of the Himalaya range. These lower rocks of the Salt Range, however, exhibit local changes, going from east to west, chiefly by the admission of new zones and by increase or diminution of thickness, and present a marked absence of all metamorphic strata. Hence it becomes a fair inference that the formations inferior to those of the tertiary belt above alluded to, and the conditions which produced them, had very considerably altered within the large area indicated; and some knowledge of the region wherein the transition commences would be very desirable. This region cannot be yet pointed out, indeed it may very possibly be entirely concealed by the newer rocks; but Mount Tilla is one of the nearest known places to the Himalaya range where the rocks next beneath the tertiary belt appear, outside or within its limits, as these may be assumed. These lower rocks appear only at the top and southern side of the lofty western part of the mountain, the extension of the ridge from this to beyond Rhotas being formed of the tertiary beds.

The section afforded by the hill is as follows in descending or natural order:—*

			Average thickness.
6.	Tertiary — Sandstone and clays chiefly, with some conglomerate beds	Sivalik ...	Only part in section, about 6,080 feet.
5.	Nummulitic limestone		Maximum 30 ,,
4.	Red shaly and flaggy zone, with pseudomorphic crystals		Very variable, about 120 ,,
3.	Pseudo-limestone and compact sandstone zone		150—200 ,,
2.	Black-shaly zone		200 ,,
1.	Purple sandstone zone	Saline group ...	250—300 ,,
	Purple shale and		100 ,,
	Red saline marl		20— 30 ,,

a knife-edge surmounting a precipice of several hundred feet in height, it was found necessary to proceed on all-fours. The wind came from the northward in such a way that much of the nearly two-miles-broad channel of the Boonhar river to the south just below the mountain would have been thought sheltered. So far from this being the case, it was here only that the gale seemed to take effect, raising vast clouds of sand, completely obscuring the distant country, while on either side beyond the limits of the mountain where the river course was not so sheltered the equally dry sand was not seen to rise at all. My guide observed, "*the winds are born on Tilla,*" and it certainly seemed as if its great mass had so influenced the temperature of the air that the storm was local, or its strength limited to the vicinity of the mountain: or it may have been an eddy behind the obstructing hill-mass.—A. B. W.

* For the purpose of comparison with the distant succession between the Ganges and Ravee, the following general section is abstracted from Mr. Medlicott's Memoir:—

Sub-Himalayan Series.

Upper ...	... Sivalik	.. Conglomerates, sandstones, and clays.
Middle ...	... Nahun	. Lignite sandstones and clays.
Lower	Subathu ..	.. Kasaoli, gray and purple sandstones. Dugshai, purple sandstones and red clays. Subathu, fine silty clays, with limestone.—*(Nummulitic).*

Himalayan Series.

Unmetamorphic—

Krol ...	... Krol Hill .	.. Limestones.
Infra-Krol ...	ditto	Carbonaceous shales or slates.
Blini ...	... Blini River	Limestone and conglomerate.
Infra-Blini ...	Simla	Slates.
Metamorphic	. .	.. Crystalline and sub-crystalline rocks.

Comparing the two sections, it will be seen that the Nahun and Subathu groups, excepting the lowest portion of the latter, are probably unrepresented on Mount Tilla; purple sandstones, if occurring at all, being quite inseparable from the remainder of the lower tertiary sandstones and clays, which, from their fossils, were identified by the late Dr. Falconer with the Sivalik rocks.

But little of the nummulitic (? Subathu) beds are seen at Tilla; and there is no appearance here of the unconformity to their underlying strata recorded by Mr. Medlicott, though this would not be reason for its non-existence. Omitting the red shaly and flaggy zone of Mount Tilla,—which is variable in thickness and not always present,—some parallel may exist between the calcareous pseudo-limestone with its underlying black shaly zone and the Krol and infra-Krol groups of Mr. Medlicott's unmetamorphic Himalayan series; but even with the aid of that gentleman's able memoir it would be hazardous at present to attempt the correlation of these rocks.

Several beds of the sections to the westward have disappeared at Tilla; notably the black-shale group beneath the nummulitic limestone, containing all the coal and coaly deposits of the eastern portion of the Salt Range, and which can hardly be said to be represented by a few traces of dark coloured shale, existing where they ought to come in.

The true red salt-marl of the Salt Range makes but a very poor show along the southern base of Mount Tilla. It can be seen in some places near the villages of Nara and Pind Sevicki, but is greatly overrun and concealed by detrital accumulations from the cliffs and hills above. Only 20 or 30 feet have been given for it in the section; the thickness would, however, doubtless much exceed this if it could be well seen. It is of the usual bright red color, and gypseous saline nature; but although salt has been manufactured from the impregnated water it discharges, no actual rock-salt has been found in it.

The upper portion of the marl is, as usual, purple, and more shaly, and is frequently seen at the base of the purple sandstone cliffs. Its thickness, as estimated, may be too great, but allowance has been made for a portion that is unseen in most of its exposures.

This shaly portion of the marl passes up rapidly into strong purple sandstones of exactly the same color. They are generally fine grained, have no pebbles scattered through them, and, from being somewhat saline, have white efflorescences, yielding easily to the weather; they contain spangles of mica; and the stronger beds, from the ease with which they can be dressed, are used as building stone. The thickness of this rock, from causes to be presently pointed out, is sometimes deceptive. It forms a very considerable portion of some of the finest cliffs, where it cannot be much less than 300 feet, though in such situations its depth could be only estimated.

Next above the purple sandstone is a strong band of dark colored gritty shales and lighter colored sandy flags and layers (2); the whole having a lumpy aspect, and glistening with mica; the deposition surfaces are frequently glossy and covered with black earthy films. In these beds *annelidan*, *crustacean* or *fucoid* markings are numerous; and elsewhere they have furnished the earliest traces of distinct fossils in the Salt Range, these consisting of small bivalve shells as yet undetermined; strong ripple-marks also occasionally occur. Resting immediately upon this shaly zone is a massive band of compact silicious sandstones and sub-calcareous rocks (3) of light color, often nearly white. Some of them are brecciated or pseudo-conglomeratic; and many, under the influence of the weather, assume the peculiar fantastic forms of decomposing limestone. A specimen of the latter variety from Mount Tilla yielded on analysis, according to Dr. Fleming, nearly equal parts of white quartzose sand, carbonate of lime, and carbonate of magnesia. Their rough aspect and a peculiar surface appearance, as if likely to contain fossils, has led to frequent searches, but nothing of organic form has been found beyond the obscure tracks noticed in the foregoing group. The beds are frequently massive; this character, their strength and the association with softer beds below, having doubtless been the first conditions that resulted in the fine cliffs along the southern face of the range. Many valuable building stones could be obtained from this group, and some are said by Dr. Fleming to bear a high polish (Jour., Asiat. Soc., Beng., Vol. xxii, p. 265).

The next overlying group (4) is largely developed only at the western end of the range. It presents a strong contrast to that just mentioned, being formed of deep-red flags and shales, sometimes spotted with green, the flaggy slabs being often studded with projecting angles of casts of cubic crystals, the mineral—in all probability salt—having been entirely replaced by sand. The flaggy layers are frequently of light color internally, the bright-red hue

being derived from the intervening earthy shale layers highly charged with iron-oxides. The latter become more numerous upwards, until the superior portion of the band is found to consist entirely of crimson and purple clay or shale. This group occupies a good deal of the ground from near Pind Sevicki by Choya Goojaron-ki, and above Nara; beyond which place it passes to the north side of the mountain, becomes thin, and thereafter is seen but fugitively here and there as well as near the summit.*

In some spots, particularly on the northern slopes of the mountain, vestiges of the nummulitic limestone group (5) so largely developed westward are apparent, resting either upon the red zone or, in its absence, upon the strong band beneath. It is seldom at all clearly seen; generally appearing as a thin white streak of debris, somewhat shifted and borne down the hill, and often overrun by other detritus; but at one spot, where rather thicker than usual, it was found to consist mainly of the white, lumpy or yellowish variety usually occurring near the base of the group. Some gray, compact beds overlie this; and there are traces of a few dark shales in its lower part, as also of a peculiar bed of compact, variegated, red and white clay rock, frequently observed elsewhere at the base of this limestone group. The rocks on Mount Tilla contain but few of the numerous fossils of the group so far as could be seen.

A small outlier of this limestone occurs below the road north-east of the houses on the summit of the hill, having subsided with the other strata along a fault; and in the opposite direction, just beneath the precipice on the edge of which the highest bungalow is perched, remnants of the variegated clay-bed before mentioned indicate that the limestone has barely been removed if, indeed, some of it *in situ* is not concealed by sub-aerial rain-wash.

The inferior portion of the Sivalik group (6), which rests apparently with complete conformity upon the nummulitic limestone, is mainly composed of strong, gray sandstones of rough texture and softer nature than any of those lower in the series. Thick beds of lumpy pseudo-conglomeratic shale also occur, and some beds of red, shaly or marly clay. Large fragments of silicified fossil wood are very numerous in some localities, particularly on top of the western end of the mountain. Over these clays comes a broad zone in which the sandstones alternate with thick beds of red clay at the northern base of the hill for fully 1,600 feet; and this zone is succeeded by another of probably much greater thickness, in which the intercalated beds of clay are of a pale brown color, there being little difference in the sandstones throughout.

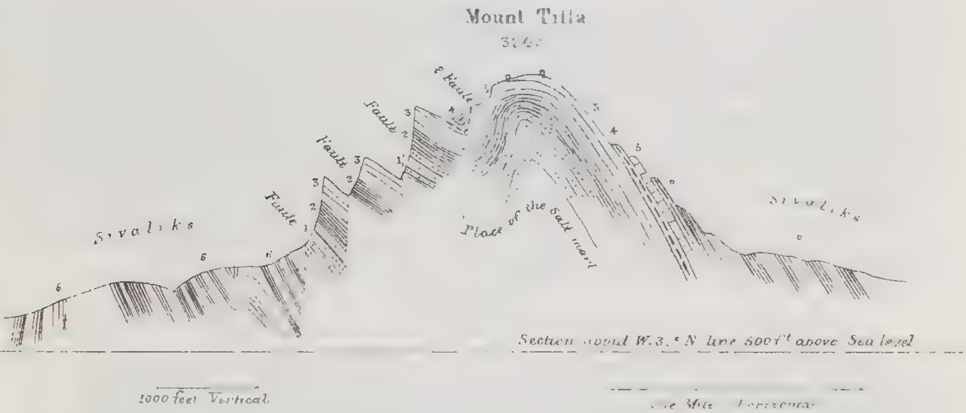
The less elevated continuation of the ridge from Mount Tilla proper on by Rhotas is formed almost entirely of what appear to be the lower portion of these Sivalik rocks, greatly crushed and contorted, generally inclined at steep angles to the north-west, but in some places more nearly horizontal; while contrary dips occur on the Jhelum (or south-east) side of this extension of the ridge.

To the eastward and east by north of Rhotas, the termination of the Tilla chain is fringed by low, rounded hills of loose conglomerate or pebble beds, mainly composed of smooth well-worn limestone and metamorphic rock debris. These pebble beds also appear, generally in a disintegrated state, in the fine anticlinal section of the Kahan gorge near Rhotas, and in one place were seen to rest unconformably upon the Sivalik rocks; but, owing to the extremely incoherent nature of the rock and its liability to have its debris re-arranged by atmospheric action, this cannot be asserted without considerable doubt; though to the east, along and near the Grand Trunk Road, the general arrangement of the conglomerate seemed discordant to the undulating dips of the Sivalik beds; while the way in which the hills were overrun with pebbles and boulders left small hope of satisfactory evidence being here obtained upon the point.

Besides the fossil wood observed upon Mount Tilla, some fine mammalian remains were formerly procured from the Sivalik beds between that and Rhotas, and were determined by Dr. Falconer, as already mentioned. A set of beds containing numerous imperfect fragments of these bones runs along the summit of this lower portion of the ridge close by the road from Rhotas to Tilla, near a place called Thurbole. The bones were found in a fragmentary state, imbedded in the matrix as well as lying loose upon the surface, but though some time was spent in the search, few useful specimens unfortunately could be obtained; and, to procure such, a subsequent and special mission would be probably required.

* The thinning out of this red zone may, perhaps, be partly due to pressure and slipping on the highly inclined slope of the beds at the north side of the hill, where the flaggy lower portion only is seen.

It will perhaps be observed that—though, as has been said, the lofty portion of the ridge of Mount Tilla coincides with a fractured anticlinal curvature of the strata which might be expected to assume approximate horizontality on the axis of the ridge—the height of the hill is given at over 3,200 feet, while the total amount of the thicknesses of groups in the sectional table only reaches about 1,000 feet, excluding the tertiary Sivalik rocks which mainly lie in the plain below and on the northern slopes of the hill. To explain this seeming discrepancy, it may be stated, 1*st*, that the height of 3,200 feet is attained by the mountain just at the point where the beds commence to turn over: 2*nd*, that the axis of the contortion rises towards the summit of the hill: 3*rd*, that 800 or perhaps 900 feet must be allowed for the height of the general southern base (the outcrop side) of the mountain, and that a considerable sloping talus above this is formed of slipped masses and debris at the top of which the section of the vertical cliffs begins to become visible. Added to these there are three, if not four, step-faults along the south-eastern side of the highest part of the hill, each of which repeats some portion of the strata, as seen in the accompanying sketch section :—



Section across Mount Tilla, looking south-west.

1. Purple sandstone.
2. Black, shaly zone.
3. Pseudo-limestone and compact sandstone.
4. Red, shaly, and flaggy zone.
5. Nummulitic limestone.
6. Tertiary (Sivalik) beds.

With regard to the physical structure of the remainder of the hill, the upper portion of the anticlinal curve expands to the west, beyond two deep coombs or glens, one of which opens broadly to the south, but enters into the very heart of the mountain; this expansion of the arch being accompanied by so slight a southerly dip that the lower members of the series present, even to the lowest of all (the red marl), appear at the base of the hill along a line which sinks gently to the west-south-west.

Along the Boonhar fault in this neighbourhood, some difference in the section is perceptible, the group No. 2 of the above figure having apparently thinned out both on the Tilla and the opposite side of the gorge: the purple band beneath seems to be also thinner; but the ground is much obscured by local slips, small faults, and large detritus from the pseudo-limestone group which, with many undulations, sheets the hilly ground or plateau about Choya.

Beyond this plateau and above it a somewhat tortuous cliff-line extends along the brow of the hill, broadly edged by the nearly horizontally rolling beds of the red, flaggy, and shaly band; while the tertiary strata of the plain beneath rise at a steep angle on the northern slopes, and, like the crest of a wave, overlap the ridge, forming most of the lofty ground westward of the summit.

The extreme western termination of the hill is very abrupt, and some complicated faulting occurs just at Pind Seviki, the last of the high ground being formed of the red, flaggy, and the underlying group, either vertical along a west-north-west line (coinciding with that of the Chambal scarp), or dipping with the steep ground at high angles to the westward, but

curving suddenly round the peak called Thob, at which place the north-westerly inclinations commence, that fix the steep character of all the northern side of the lofty ground. Round this peak of Thob, too, as a centre the strongly marked strata of the Sivalik (tertiary) group are boldly curved so as to enfold those which form the hill; the former, all more or less on edge, being frequently so perfectly vertical that all trace of their outward dip is lost.

At the north-eastern extremity of the lofty ground the dislocation of the rocks is accompanied by violent contortion both of the Sivalik and older beds, its intensity diminishing considerably along the lower extension of the ridge to the north-east.

Gold is said to be washed from the sand of the Boonhar river. Its source is probably among the Sivalik sandstones and conglomerates, formed of Himalayan detritus. The washing is carried on after rain.

The summit of Mount Tilla, though affording small space of at all level ground, will doubtless attract attention as a sanitarium within easy reach of the Military station of Jhelum. It commands a splendid view of the snowy Pir Punjal range; is said to be, and most probably is, much cooler than the plains, for when visited on an extremely hot April day, the temperature in the shade was very refreshing.

A road in excellent repair, save where it passes through the tertiary ravine-ground near Dariala, leads from Jhelum to the houses on the summit; and the hill, though by no means completely bare on top or on the northern slopes, is not crowded with jungle.

The chief difficulty, as usual, would be a large and continuous supply of water. Extensive tanks exist, one of which is well placed, but lies rather low in order to obtain a catchment basin. The disposition of the strata affords little encouragement to sink wells; though the black, shaly zone might be found retentive. Some springs there are, and others might be found, where the tertiary strata cap the ridge, but this is at a distance of from four to six miles, and a road would have to be made to them, so that probably the best method of increasing the supply would be by multiplying the number of tanks and making them as little liable to leakage as possible, one large structure of the kind on the north side of the hill having been found quite empty, owing, as was said, to this fact of its leaking.

THE COPPER DEPOSITS OF DHALBHÚM AND SINGHBHÚM.

The following papers on these copper deposits consist of, 1*st*, abstracts of two papers by M. Emil Stœhr, the accomplished mining geologist employed by the Company formed to work the mines; one in the "Vierteljahrschrift der Naturforschenden Gesellschaft" in Zurich, Vol. V, p. 329, 1860; the other in the "Neues Jahrbuch fur Min. Geo. u. Pal." for 1864; and, 2*ndly*, a recent report by Mr. V. Ball, of the Geological Survey. Scientific observations in connection with mining operations in India are so rare that it is important to place the experience and the opinions of M. Stœhr on record in a form easily accessible to the Indian public. The works being abandoned, the mine-sections were not accessible to the Geological Surveyors. The localities mentioned by M. Stœhr may be followed upon the map attached to the second paper.

1.—THE COPPER MINES OF SINGHBHÚM, by M. EMIL STŒHR.

1. *General Geological features: Schists.*—It is only in the south and west of the region under notice that granite and gneiss-granite appear, forming dome-shaped hillocks seldom more than 100 feet above the flat. The old rock-formations—metamorphics—of Lyell behave very differently; they form a system of parallel ridges from west-north-west to east-south-east, ranging in elevation to 1,900 feet and under. The strike of the ridges is for the most part the same as that of the schists, except in a few places to the east; up to Sideshor the strike varies from east-7°-south to east-30°-south; from there it is east 37°-to 60°-south. The dip is constantly to northwards, at from 15° to 50,° mostly from 20° to 35°. This structure decides the form of the hills—steep on the south and sloping on the north.

These schists present many varieties, scarcely any form of metamorphic rock is unrepresented; clay-slate of the most various types, from soft clay-slate to roofing slate, with quartzose varieties, or sometimes quartzites, forming the ridges; mica-, chlorite-, talc-, hornblende-, and quartz-schist with quartz-rock are the most prevalent. Occasionally gneiss is found, but without any continuity or constant position in the series. There is a peculiar rock composed of round grains of quartz in great number (often exceeding the matrix) in a base

of clay-slate. At the junction of the sedimentaries and the granitics there occurs a strange quartzose formation, a true arkose, many feet thick and almost vertical; in which are found angular fragments of the different metamorphics, in a fine quartzose mass. Of minerals I obtained garnet, schorl, kyanite, rhatizite, and chloritoid (of Kenngott); also a blue-black mineral of an elongated form, which Kenngott considered to be apatite united with a carbonaceous substance.

2. *Greenstone dykes.*—The irregularities that these ranges exhibit are due to the presence of transverse dykes, especially of diorite. Simple inspection cannot determine whether the greenstone is amphibolic or pyroxenic—diorite or diobase; I incline to consider it diorite. Generally hard, it often becomes soft, changing to aphanite; at Paraum near Dhoba it is almost serpentinous, containing nearly 10 per cent. of water. Not far off are considerable runs of potstone, which this aphanite seems at all events to approach. In other places the greenstone passes into greenstone-schist, following the strike of the series. Although these dykes do not always come to the surface, they can be traced at intervals in long ridges recognisable from a distance as longitudinally extended lines of conical hills, generally double-topped. The strike of these diorite masses varies, generally north and south, or 15° on either side. Where such a north-south range crosses those of the older rocks all is confused; still a most picturesque conical hill always detaches itself from the mass. This very hornblendic diorite has a remarkable tendency to spheroidal structure, and appears on the summits split into vertical columns, like ruined castles. It is noteworthy that one often finds such clefts with quite fresh surfaces of fracture: this is the result of the sudden cooling by rain of the rocks when highly heated by the sun's rays, as I determined by direct experiment. These diorites are so rich in iron that they often disturb the magnetic needle, and weather into iron-sand. The diorite cones seldom form considerable elevations; but this is not without exception, as at Bagmuri, 2,000 feet high. Where the diorites come in contact with the sedimentaries these are altogether metamorphosed; basalt-jasper occurs; the schists are calcined, and columnar divisions are frequent. These greenstones are not limited to the north and south dykes.

Whether the introduction of the greenstones has had any connection with the appearance of the copper ore must for the present remain undetermined; it would seem the more likely, inasmuch as the potstone and serpentine formation is certainly so connected.

3. *Granitics.*—These diorites run into the granitic area to the south and west; where gneiss-granite and, less frequently, true granite form dome-shaped hills; these also here observe an east-west direction in long parallel ranges above the plain, traversed by the north-south diorites—an arrangement that gives to the whole area a strange chessboard-like aspect. At the intersections of the two systems of ranges, the most picturesque cones occur; and remarkable development of mica appears in the granitic rock, so that the mica is applied to many ornamental purposes.

4. *Laterite.*—In India many different formations are grouped under the name of laterite. There is the laterite of the plains formed of detrital matter into which the iron constituent came from without, probably from springs; such is the laterite of Midnapur. From these are to be distinguished that which owes its formation to the decomposition *in situ* of ferriferous rocks; such is the only laterite known to me in our district, as on the summit of Mahadeo, derived from the ferriferous diorites.

5. *Mineral products.*—I have already mentioned the potstone that is worked into various utensils. I may here notice an ochreous schist that is used as a dye. Of ores there are—iron ore, sometimes as a vein, sometimes stratified; mostly pure magnetic iron (see Berg- und Huttenmännischen Zeitung for 1863); seldom red hæmatite, and once only brown hæmatite; then the rich copper ore, which was the object of my journey to India.

6. *Copper ore: its range.*—This copper ore would be interesting if only on account of its unusual longitudinal extension—for 80 miles if not more. I have examined it more closely through a length of 65 miles, from Lopso hill in the west to as far as Badia in the east. I know nothing of its further distribution in the western forest-clad hills, but in its eastern range it goes far beyond Badia to Bairagurha, the most south-east point on my map; and so far as I examined the intermediate hills, traces of the ore were found everywhere; but in its longitudinal range, it appears most in the northern hills.

7. *A lode, or bedded.*—The strike and dip so coincide with those of the containing strata that one is induced to consider the mineral deposit as stratified; against such a supposition there is the vein-like mode of deposit, the frequent cuirasses and slickensides, the occurrence of druses, and the broken outcrop. At all events the deposit is a filling of

cracks parallel to the layers of the containing rock; and the formation of these cracks was probably contemporaneous with the upraising of the schists. Following the structure of the containing rock, the deposit was originally variously irregular; and this condition was aggravated by the intrusion of the diorite.

8. *Several outcrops.*—Proceeding from north to south there frequently appear two or even three consecutive runs of copper ore; it would thus seem, partly that one and the same band was brought several times to the surface by upheavals, partly that a system of parallel deposits truly exists. At all events we can recognise at several places two parallel ridges, or lines of outcrop, sometimes miles apart, sometimes coming so close that they almost commingle. Going from west to east we find, quite to the west, near the Lopso hills, two runs of ore scarcely ten minutes from each other; a third more northern locality seems only due to a local disturbance. These two runs separate to eastward, being several miles apart at Khursowa, until they appear to come together again in the Akarsuni hill. From there to Tamba-dungri (copper hill) the deposit is buried beneath the deep soil of the plains. At Tamba-dungri one run appears which can be traced over Jamjura, then bending southward to Landu, and then again northwards to the summit of the conical hill Chundra. A little north from Jamjura a second band shows, which runs northwards from Landu to Chundra, at the summit of which these two runs are scarcely two fathoms apart. From here the two separate again, one goes south to Matku in the plain, where it is concealed; one to Hitku, Banka, etc., in the north flanks of the Rangi hills. Here there is a break of several miles where I was not fortunate enough to find the ore: finally it appears again at Racka and proceeds then in a long line following the north hill-flank. Between Bindrabun and Sideshor the strike alters, from east-37°-south to east-60°-south; also the intruding diorites disturb the rocks much, and with them the deposit. In their further course eastward the hills trend rather back, and the deposit gets gradually into the plains. At Pathur-ghora, we find again two lodes, probably, however, only the broken parts of one and the same main lode which unite at Bairagurha. From here all goes straight, except once at Karapathur there is a disturbance; the contorted and crushed strata are confused and the rock almost altered into gneiss. These schists are stuck up to north by a south to north upheaval, and twisted round the Karapathur, till at last all becomes normal again.

9. *Varieties of the ore and gangue.*—As for the ores themselves:—when removed from the influence of the atmosphere the iron ores are, mostly magnetic iron, less often pyrites: the copper ore, too, is seldom pyrites, mostly glance-copper and red copper ore; either ore indeed is seldom pure, but mostly the two in intimate variable mixture, so they almost form a peculiar ore of blue-red colour, soft, and with red streak. According to several analyses (among others by Fresenius and Roth of Heidelberg) the proportion of sulphur varies from 9 and more per cent. to complete absence; and also the total of copper from 42 to 64 per cent.; the ore is always contaminated with iron, from 5 to 12 per cent. It seems that when sulphur is quite absent, glance-copper is also wanting and the red-copper is not pure but mixed with black-copper; also in many places black copper occurs in strings and disseminated, and is used by the native beauties as a black dye for the teeth. Beautiful rosettes of red-copper appear detached, no doubt the result of decomposition. In the upper levels the saline ores occur as the result of alteration, malachite, less often azurite, and brown spar. The whole gangue and ore are often so decomposed that these products are formed to a depth of 15 fathoms. As a ternary product of decomposition, on the heaps and scattered, I may mention chrysocolla, libethenite, and chalcophyllite.

I must again notice the intense atmospheric action; often at the depth of 30 running fathoms the decomposition had not ended; the earthy quartzite-schist had become decomposed and penetrated with malachite and brown iron ore.

Malachite, in solid masses, compact and earthy, seldom fibrous; in the upper levels the only ore, where it occurs in film and fragments, or mixed with brown hæmatite, impregnating the whole gangue, which then contains from 2 to 8 per cent. of copper. It occurs besides as infiltrations in cracks and slender clefts where a rich deposit ends or begins. It is always more or less mixed with silicious earth and ochre; the purest pieces give—

Oxide of copper	51·73
Iron oxide	6·20
Water	6·87
Carbonic acid	15·15
Alumina	·83
Insoluble	15·95
	99·73

Red copper ore, in solid masses from the size of a nut to several feet in diameter in a silicious matrix, sometimes filling the whole lode and enclosing angular pieces of quartz, sometimes in strings and flakes ramifying through the rock. This is the most important ore, seldom indeed pure, almost always mixed with black copper and iron oxide. As the malachite is due to the further decomposition of this ore, so is it of glance-copper; some specimens show the three states. It is difficult to find red copper entirely free from copper-glance; apparently pure red copper specimens have given 8 per cent. of sulphur. The mixture with iron oxide varies from 0·25 to 18 per cent. It is too always mixed with black copper; and it was interesting to know if the proportion were constant; analysis showed it to vary from 63·7 per cent. sub-oxide and 33·6 of oxide to 50·11 per cent. of sub-oxide and 46·71 of the oxide. It is only an indefinite mixture. Often the oxyde is in excess, the ore being dark brown, with black metallic streak. The common variety is brown red to cochineal red, with red streak, and in pure pieces, a fine crystalline texture. This quality, with hardness of 3, sp. gr. 5·623, gave—

Sub-oxide ...	63·72
Black oxide	33·60
Silica	1·02
Alumina and iron	0·75
Lime	0·64
Magnesia ...	0·10
	99·83

Others gave traces of manganese and bismuth.

Black copper occurs only as a coating, and at most in strings as thick as the back of a knife and always mixed with red copper and iron oxide.

Copper-glance, massive, mostly in kernels. It is at all events the original undecomposed ore; seldom pure, almost always with iron oxide.

Copper pyrites seldom found; and only sprinkled here and there.

Azurite, as a crust. It is remarkable how seldom it appears where malachite is so abundant; I only know of one locality.

Libethenite and *Chalcophyllite*, in small crystals in the old refuse heaps; similarly *Chrysocolla*.

Native copper, in massy rosettes and flakes; rare, and only where surface water can penetrate; associated with malachite, of which it seems to be a reduction and not of red copper.

Copper uranite was found on Lopso.

Iron ores.—Brown iron ore; in the upper levels often filling the whole lode, as ochre or as solid brown hæmatite.

Magnetic iron in crystalline granular masses, sometimes even filling the whole lode mostly mixed with specular iron (Eisenglanz). Analyses of fragments of the old copper regulus gave traces of silver and gold, and 10 per cent. of iron. Assays made in London proved the ores to contain silver: an ore of 31 per cent. of copper gave 0·0078 per cent. of silver, one of 60 per cent. of copper gave 0·0039 of silver. The silver then cannot be principally contained in the copper ore, but in the gangue.

10. *Distribution of the ore.*—Copper is not the only metal this deposit contains; iron predominates; so that one may describe the deposit as one of iron ore rich in copper. The copper-contents are themselves very variable, from traces up to the richest ore. The action of the intruded diorites appears to influence the proportion of copper; they may come quite to the surface or only produce a north-south upheaval, the richest copper deposits always being in their neighbourhood. In the preponderating quartzose gangue the ores occur in leaves or threads, from paper thickness to several inches, ramifying through the mass; sometimes binding angular quartz fragments, sometimes in compact masses; often filling the whole vein. Elsewhere they show in lenticular lumps from the size of a hazelnut to that of the head, having then generally a covering of talc or chlorite in the quartzose base. Sometimes, but seldom, the quartzose veinstone fails, and contorted, crushed, broken chlorite- and talc-schist enclose lumps of quartz and strings and pieces of ore. Once or twice the veinstone was quite porphyritic.

The roof and floor of the deposit are not confined to any particular kind of rock of the metamorphic series; many different rocks occur as such,—clay-slate, chlorite-, talc- and mica-schist; but always a schist; quartz rock never occurs as roof and floor. The strike is the same as that of the rocks; in the west, from east-west to east-35°-south; in the east so much as east-60°-south. The dip is 15° to 50° to northward, mostly 20° to 36°. The normal width of the lode is 20 to 22 inches, at which the ore is richest; sometimes filling the whole vein. It often expands to three feet and over; but then the ore scatters and the richness suffers. Whether a workable ore extends, and how deep, is unknown; the ancients only worked that nearest the surface; but wherever I opened old works and went deeper good ore was found, generally after cutting through some poor ground, so that at 100 to 120 feet the ore still always held out. At the time of my departure the point at which research had been carried farthest was at Landu; there 212 feet had been reached, but already at 190 feet the ore had decreased, and at last was quite lost. Whether there only happened to be poor ground at this spot, or whether generally the ore does not extend to the deep, is unascertained: I would almost decide for the latter opinion. The deposit is of course not worth working throughout its entire extent; but rich parts alternate with poor or even with barren; to find the first was therefore the chief endeavour; and we were successful at many points in finding such rich localities.

In the Lopso and Sirsu section the ore is associated with quartz- and mica-schist.

At Podumpur with a sandy mica-schist containing schorl.

At Akarsuni with black mica-schist and quartzose clay-slate, close to greenstone; granite also shows in the neighbourhood. The detritus on this granite is washed for gold.

At Tamba-dungri, a greenstone that does not reach the surface seems to have raised the schists and partly metamorphosed them locally into gneiss and quasi-granite, and the ferruginous schist into jasper. The top of the hill is burrowed all over with little pits 60 feet deep.

The northern run at Landu is in quartzose schist accompanied by mica-and chlorite-schist: the southern in mica- and chlorite-schist with associated quartz.

At Chundra the ore occurs with quartz gangue in mica- and chlorite-schist and quartzose clay-slate.

At Matku in the quartzose clay-slate and quartz-schist.

The northern lode at Chura-dungri and Hitku is in quartz-schist; at Pahlu-dungri in chlorite-schist; at Banka it is greatly disturbed and seems to be cut out suddenly by a mass of potstone.

At Racka and Bagh-ghura the rock is sandy schist and quartzite, but mica-, chlorite- and talc-schist are not absent. It was here that disthene-rock was found. The ore is in a silicious schist and occasionally in mica- (black mica), actinolite- and chlorite-schist.

At Sukurna, near Sideshor, the ore is in silicious schist, associated with mica-, chlorite- and quartz-schist. Sideshor appears to be the production of a penetrating north-south upheaval; and in its quartzites traces of the ore are found, as malachite,—a proof that many beds of the metamorphic series are cupriferous. At Bindrabun immediately under the ore is a massive rock composed of quartz and tourmaline with a little mica,—a granite formation, except that felspar is wanting; one might almost call it greisen. A run of jasper occurs close by, in the formation of which, as well as in the elevating of Sideshor, this peculiar rock may have taken part. Malachite traces are found in it too.

At Pathur-dungri the rock is quartz-schist; but on the south-west of the hill ore occurs in mica-, chlorite-and hornblende-schist.

At Súrda the ore is in dark mica-schist containing garnet, chlorotoid, and hornblende crystals. Near Pathurghora the ore is in more or less metamorphic schist; near the village red felspar is associated, and the rock becomes granitoid.

The distribution of the ore in the lode follows no certain order; unless one is to consider as such its constant association with quartz, which is always the preponderating gangue. From the agreement of the dip and strike of the deposit with that of rocks, one would consider it as a stratified ore, were there not much against such a supposition. I do not here allude to the cuirasses and quartz druses, but especially to the variable strength of the deposit itself, and the interruption and separations of the outcrops; which then again follow

the strata and lie in many patches close to each other. The normal thickness may be about 20 inches; in rich spots it reaches 3 feet; while elsewhere it intermits, the deposit is compressed and decreased with only scattered ore, till this also disappears and the deposit can no longer be traced. All this suggests to me separate lodes, *i. e.*, an impregnation of cracks parallel to the rocks, and probably formed at the time of their elevation.

11. *Peculiar carbonaceous mineral.*—I conclude this short description of the deposit with a notice of a mineralogical peculiarity occurring in it. At Jamjura the lode was sought for beneath the thick soil of the plains, and found with good ore. In this newly opened work a fault was struck, in the neighbourhood of which the veinstone seemed quite altered, the quartzose mass had become almost porous, the quartz had lost its lustre, and had become almost friable. In this rock and in the ore itself there occurred as rarities in, as it seemed, octahedral or rhombohedral cavities, loose pieces of a peculiar coal-like substance. It was found at 37 feet below the surface, or at 100 feet along the slope of the deposit, at 30°. I had early sent from India some specimens to Bergrath Breithaupt at Freiberg, who has described this strange mineral in the Mining and Metallurgical Journal for 3rd January 1859, from which I here give an abstract of the principal characters:—black; semi-metallic lustre on fresh fracture; black streak; opaque; blunt pieces of size of an egg and under; internally crystalline, very fine grained; sp., gr. 1·92; hardness 4·25 to 4·75, between calc and fluor spar; brittle; very difficult to burn before the blowpipe. Composition, mean of Sheerer and Ruhe:—

Carbon	93·945
Water	1·440
Acid	2·895
Ash	1·720
	100·

It is considered by Breithaupt as a middle condition between anthracite and graphite.

Breithaupt thinks that the tabular impressions on the carbon may be due to calcspar—that in the druses calcspar crystals were produced. This is surely an error, for I never saw such crystals; on the contrary, the coaly matter is loose in cavities lined with lamellar quartz, which is often imposed upon it. The hardness given by Breithaupt is not correct for all the specimens; many are easily scratched by calcspar. I would mention that I possessed a piece of veinstone which together with this mineral contained undoubted flakes of graphite, as also two different forms of the mineral close together.

Professor Kenngott and Escher de la Linth have more closely examined this substance; on the same veinstone were found white particles of a silicious substance with a deep black nucleus, the white exterior being the result of decomposition; hence Professor Kenngott takes this substance to be the remains of the decomposition of a highly carbonaceous silicious mineral, whereby the silica was removed, leaving the carbon.

12. *Mining experiments.*—In order to exhibit the special conditions of the deposit I will now describe the most important mining experiments. Special mining experiments could not be attempted over the whole area within little more than three years' time: they were limited to between Jamjura and Rangi. Landu was the centre; there were extensive old works there, and the flat ground offered an untouched field for exploration. The diggings that gave the best opening were No. 1, near Landu, in the north lode. At 7½ running fathoms we got to the end of the old workings, where the width, originally considerable, was reduced to 15 inches. There was great trouble in getting the men to continue the work; and when, among a lot of jackal bones, a piece of a human skull was found, all green with copper, great terror spread, and only the most pressing representations, that the skull must have been brought there by some beast of prey and did not belong to a man who had perished on the spot, could induce the men to carry on the work. The layer was only 15 inches from roof to floor, almost filled with rotten slate and quartz fragments, rich in iron, but almost without copper, only here and there a sprinkle of malachite incrustation. The ancients had evidently abstracted all the good ore till they came to this barren run. After a little the malachite increased, enveloping the quartz, and so ramifying through the still broken schist that it yielded from 1·8 to 4·5 per cent. of copper. The roof and floor were of chlorite-schist, quite devoid of copper save by infiltration in the little cracks. At 12·7 running fathoms strings of malachite occurred one-half of an inch thick; and the lode was 2 feet wide. From here it increased; and at 15½ fathoms an easterly drift was started that soon disclosed the most splendid ore; first malachite, then this passing into red-copper, and this again into glance-copper. This ore finally filled the

whole vein, 3 feet thick, enclosing angular pieces of quartz; and also occurred in large elliptical nodules several feet in diameter lying in a gangue of silicious slate, in such numbers that a fine roof-face could be worked; at 25 fathoms along the drift, the lode split, one branch going southwards soon became barren, while the northern one yielded fine ore. In a northern trial-drift from here another vein was cut more or less rich in ore, and still further eastward three others. Down from this drift a small hading shaft was sunk; and here, at 28½ fathoms the ore began to decrease, and died out altogether. So far the underlie was 35°; here it rose to 60° or 70°; the thickness of the lode decreasing to a few inches; below this trouble it became flatter again and traces of ore re-appeared, till at 32 fathoms this too disappeared with a new trouble. It was in this state of affairs that the hand pumps could no longer keep under the water of the rainy season, and the progress discontinued at 12 fathoms vertical from the level of the valley.

Four miles to the west, at Jamjura, under the alluvium of the plain, a very rich ore was cut, occurring in a very similar manner to that at Landu. At 18 fathoms the ore was still good. In a westerly direction it was less rich, but continued to eastward. In a trouble of this vein the carbonaceous mineral was found; not only in quartz, but in solid malachite. Here, too, was found the native copper, reduced from malachite by the action of this carbon.

A third important locality was No. 6 of Landu, in the south lode; chlorite-schist and sandy mica-schist contain grains and nodules of quartz, often coated with talc; these are sometimes several feet in diameter. In and around these generally flattened lumps, partly following the layers of the schist, partly, too, itself forming kernels, or surrounding fragments of quartz, comes the ore in threads, from the thickness of a knife to several inches, thus uninterruptedly arranged in nuts and lumps, and in this manner forming the lode, 18 to 24 inches wide. These conditions obtained to 16 running fathoms, then the ore ceased, and at my departure the work was in barren rock. In the upper part the ore was all malachite, but in the hard undecomposed masses there was a mixture of red and black copper with glance-copper. The ore was besides always very rich in iron. At about 80 fathoms to the east, in a small trial pit, the lode was almost entirely made up of coarsely granular crystalline magnetic iron.

At Hitku in the northern, and Matku in the southern, lode there occurred quartzose, porphyry-like gangue; and the ore predominated as nodules of oxides, with glance-copper. In neither place was it worth working, appearing to cease in depth.

At Banka a clear-ringing, columnar, fissured quartzite is penetrated in every direction by thin strings of ore, black, with glance-copper. Sometimes it is scattered through the quartzite, giving it a porphyritic aspect; the quartz being then altered, dull, fragile as if burnt. Low down there appeared an agglomeration of quartzose talc-schist and nearly massive talc, where the lode stopped out suddenly.

According to the results at Landu, the cubic fathom of 96 to 150 cwts. of raw ore gave an average of 6 per cent. of copper; and the cost of extraction of the same, including haulage, amounted to Rs. 22 to 23 per 100 cwts. of raw ore.

The preparation by hand-picking must be regulated according to the proportion of saline ores; here the average of 100 cwts. of raw ore was—

3	cwts. of rich picked ore of	20 to 35	per cent. copper.
60	,, average ore of	8 ,, 9	,, ,,
13	,, dust ore of	0 ,, 5	,, ,,
24	,, rubble and poor ore of	¾ ,, 1½	,, ,,

All the poor ore was considered as rubble for crushing. In the best rubble there occurred but 8 to 10 per cent., very seldom 20 per cent.

13. *Labour.*—Most of the coolies were Dhangha Kols. On the whole, they proved themselves very intelligent and skillful; on an average more so than our European workmen; only they are weaker; but, whether mentally or bodily, they are very slothful, so that they require constant watching. The daily wage of a workman is 4 to 6 pice; with which they receive the powder and tools supplied; yet job-work was only undertaken by experienced workmen. The gang at one face could not amount to less than four to six men. It was impossible to get the people to work uninterruptedly, so that a face 1½ fathoms high thus worked only advanced 0-8 of a fathom monthly.

14. *Prospects.*—Since 1862 great endeavours have been made in London to get up a limited company with £120,000 capital to work the Singhbhúm mines. The original company

had dissolved about 1859; its history was this: after Captain Haughton in 1854, in the Journal, As. Society, Bengal, had first called attention to the mineral treasures of the district, two Calcutta merchants resolved to start mines, and I went to Bengal by their instructions to make investigations and to establish the mining. When it was certified that at many places fine ore occurred a company was formed in 1857, having at its head the two original firms; and everything was then started on a very great scale. Mining commenced at Landu and Jamjura, and fine raw ore was turned out at the rate of 1,200 to 1,300 cwts. monthly. Other works were at that time not yet opened and in order; still already the erection of a foundry with steam engine at a great cost was insisted on: and consequently, after my departure, what was expected befell: there was not yet enough ore there for the supply of a large foundry; the company dissolved in 1859; and the stores, building, and machinery fell to a transferee at an insignificant price. So very costly a management had only accelerated the dissolution of the company. In India every administration is costly: here it was the case in a remarkable degree, as this single circumstance fully proves Rs. 9,200 had to be paid yearly to the two rajahs of Ghatsilla and Seraikela, in whose land the works were situated, for the right of mining and smelting.

As above stated, since 1862 great exertion has been made to form a grand new company; and in the prospectus mention is made of my name with reference to my report to the former company, so I do not hesitate to declare that without further information than that already known and established—so long as nothing positive is settled regarding the continuation of the ore in depth—the formation of a company with a capital of £1,20,000 is unwarrantable. Ore, and very fine ore, is undoubtedly to be got; and the works already undertaken might be carried on to advantage in spite of the deficient communications, if with moderate expectations an economical enterprise be undertaken, but for this so colossal a company is not suited. If the works are to be again established, mining experiments should be extended before everything, and according to the results thus obtained such a company might be formed or not. No one could expect an exhaustive judgment from the works already accomplished, and considering the time spent upon them, the first surface labor took place in the end of 1855, and already in 1859 all was discontinued.

15. *Ancient mines.*—Almost wherever the deposit comes to-day and is not concealed beneath the alluvium one finds old buildings and refuse heaps, where there was formerly a mine. In spite of the rudeness of the mode of extraction the work must be admitted to have been sagaciously conducted. The ancients never went deep; sometimes hindered by the water which everywhere is reached below the level of the valleys, sometimes by the fear of working under ground. The use of powder in blasting must have been unknown to the people of that time, for I everywhere found in the old works, where open, single pillars undisturbed, very rich in ore, but in such hard rock as only to be won by blasting. The ancients seem to have smelted the ore in little furnaces on the spot, for one finds remains of walls, heaps of slag, and even copper bloom in many places. It is impossible to determine the age of the old workings; the heaps and fallen-in pits are mostly overgrown by thick jungle and covered by old trees; only here and there one finds large openings in the rock, at present the refuge of crowds of bats, whose dung covers the floor more than a foot deep; the cavity itself being converted into a beautiful green hall by a thick crust of malachite. If one asks the inhabitants when such work was in progress, they do not know; and they speak of 100 years with the vague ideas of Asiatics about time, representing thereby an arbitrarily long period. It seems to me, however, certain that the present half-wild inhabitants are not in a condition to carry out such works; and these may be the relics of an ancient civilization, like the rock-temples of the neighbouring Orissa, like the fruit trees (mango and tamarind) that one often finds as very old trees in the middle of the thickest forest; as again the remains of the great town Dulmi, which once stood in the thick woods of the Subanrika. Only one story has reached me of the ancient mines. Where from the lofty Sideshor, the ridges of Bindrabun, Ruamgurh, and Mahadeo descend into the valleys as spurs, one finds on Bindrabun extensive old diggings and pits, and on Ruamgurh slag-heaps and remains of brick walls. There, at Ruamgurh, a rajah of the name of Ruam must have lived and have made the diggings and houses. In the story this rajah is reported to have had two tongues,* so I must consider him as a person who spoke two languages, in fact a foreigner. The period may have been the 11th century, when the Kingdom of Orissa flourished.

* For another explanation of the two tongues, see a paper by Mr. Ball, Proc. As. Soc., Bengal, June 1869.

2.—ON THE COPPER OF DHALBHÚM AND SINGHBHÚM, by V. BALL, B. A., Geological Survey of India.

The district of Singhbhúm, first brought to the notice of the British in the year 1820, when the internal disturbances rendered interference necessary, was not placed permanently under British officers until 1836. In the interval that elapsed between these two periods, the discovery of copper and ancient native copper mines appears to have been made.

The first published intimation of the existence of copper in Dhalbhúm was given in 1833 in a paper by a Mr. Jones* who was engaged in making researches regarding the coal of Bengal. He writes—"I have reason to suppose copper may be found in Dhalbhúm near Ragwaha (Rajdoha) in a stream called Gura Nadi that empties itself into the Subanrika." Whether this supposition, which subsequent investigation has proved to have been well founded, was based on information received from natives or from personal observation we are not informed.

In the year 1854, the existence of extensive copper deposits which had been much worked by the ancients in the above-named districts was forcibly impressed upon public notice by Captain now Colonel J. C. Haughton, Assistant to the Governor General's Agent in the South-West Frontier.†

In the same year the mines were visited by H. Ricketts, Esq., C. S., who proposed to Government that "a small sum be expended in working for a short period in order thoroughly "to test the produce and to show the people of the country how to turn the veins to the "best advantage."

M. Stœhr in the paper printed herewith details the circumstances under which he came out to this country and the steps which led to the formation of the first Singhbhúm Copper Company. Since his return to Europe, this company ceased operations in 1859; and a second, formed on the ruins of its predecessor, lasted only from 1862 to 1864, when it also was dissolved.

In 1857, M. Durrschmidt published a report (with a map) on the "copper mines of Singhbhúm." All the important part of the information is derived from Colonel Haughton and M. Stœhr. Some of the minor details would be of interest only to persons purposing to re-open the works. Speaking generally, this report takes a much more favourable view of the prospects of mining than was justified by the facts available at the time.

In the prospectus of the second or Hindostan (Singhbhúm) Copper Company, a number of analyses and opinions regarding the quality of the ore by various assayers and others are quoted. These or rather a portion of them will be found incorporated in the following pages.

The fact of the copper ores having been worked by the ancients has been above alluded to. It is probable that the greater number of old excavations enumerated in the table on p. 100 are of considerable antiquity. Elsewhere‡ I have discussed the reasons which have led me to the conclusion that the ancient workers were an early Aryan race called *Seraks*.

Within recent years a rude kind of working has been undertaken by the local rajahs and zemindars. But in consequence of poverty of the ore, flooding of the mines, want of labor (the pay perhaps being neither liberal enough nor regularly bestowed), or finally, as has sometimes been the case, sudden discovery on the part of the rajahs that their dignity was being compromised by the work, all such operations have been discontinued.

Geology.—In order to render the following account intelligible, it will be necessary to give a brief sketch of the geology of the district in anticipation of the full account of it, which will be published when the examination of the whole area shall have been completed.

The rocks of Singhbhúm, so far as they have been examined, are referable to two formations. The metamorphic, consisting of granitic and foliated gneiss, schists, &c., and the sub-metamorphic, consisting of slates, quartzites and schists, which latter are sometimes not lithologically distinguishable from those belonging to the metamorphic.

In Manbhúm, exclusive of the coal-fields, something less than four-fifths of the area is occupied by metamorphic rocks. In the remaining fifth at the south of the district the

* Asiatic Researches, vol. 18, p. 170, 1833.

† J. A. S. B., XXIII, p. 103, 1854.

‡ Proc., A. S. B., June 1869, p. 170.

sub-metamorphic rocks are let in by an east and west fault; thence southwards they pass into the district of Singhbhúm, where they cloke round irregular areas of metamorphic rocks. The principal of these areas lies east of the station of Chaibassa. The rocks seen are coarse granitic and porphyritic boss-forming gneisses which are traversed by a perfect network of trap (diorite) dykes. This combination produces a very peculiar effect which, as seen from the top of a high hill, has been aptly compared to a chessboard. The walls formed of trap dykes constitute substantial boundaries between adjoining properties. North and north-west of Chaibassa there is another area of the same metamorphic rocks which is, however, free from trap or nearly so. A third small area exists near Khursowa, regarding which something will be said again further on. The appearance of the sub-metamorphic area is very different from that just described; it is characterised by being traversed by long ranges of hills with deep intervening valleys which correspond to the position of the softer varieties of rock of which the formation is composed.

The copper ores to which this account refers occur for the most part in a zone of schists whose geological position is situated near the base of the sub-metamorphic rocks. These schists form the northern flank of a broken spur of hills which leaving the Chota Nagpúr plateau strikes eastwards for a distance of 40 miles through the estates of the rajahs of Khursowa, Seraikela, and Dhalbhúm, then bending round gradually to south-east and ultimately to south, it disappears under the alluvium of Midnapur.

The principal ranges composing this spur are of quartzite, upon which incrustations of the copper salts are occasionally found; but the ore which has been worked is, with a few exceptions to be noted hereafter, associated only with schists.

Measured along the strike, these copper-bearing rocks extend for a distance little short of 80 miles. Copper ores have not been discovered west of Lopso; but there is no geological reason why they should not be found for many miles further in that direction in the Chota Nagpúr highlands.

In the tables appended an abstract is given of the principal facts which have been observed at the various localities in which the copper has been found. And in the accompanying map all these localities are indicated. M. Stœhr's paper contains all the available reliable information regarding the working of the mines.

The determination of the question as to the manner in which the copper occurs, whether in lodes or as a deposit, is one of no less difficulty than it is of importance. M. Stœhr holds the opinion that it occurs in lodes, though admitting that much may be said in favor of the opposite view. He describes the variable strength of the deposit itself and the interruption and separation of the outcrops which in some places are close to each other. Carrying out this view, he distributes the localities where ore occurs along two lodes which he calls the north and south. He alludes to the fact of the existence of particular beds of rock in the vicinity of the copper showing signs of excessive metamorphism which he considers to be due to local action; but he does not mention that the copper, if followed along its line of strike, is found to penetrate into areas occupied by rocks which are undistinguishable in their lithological characters from the most crystalline rocks occurring in the older series. Of course it may be that these, like the single beds above mentioned, have been affected by local metamorphism, possibly caused by the intrusion of granite, but the granite which occurs is not distinguishable from that which is often found in Bengal to alternate with well foliated rocks, and is therefore believed to be of metamorphic origin. Thus this circumstance, which might otherwise be used as a crucial test of the validity of the lode hypothesis, is itself so uncertain and fraught with doubt that it is a rather dangerous description of evidence to make use of in such a discussion.

In support of the view that the copper partakes of the nature of a mechanical or chemical deposit in the beds, there is the fact that the underlie of the ore as seen at the surface nearly always appears to correspond with the dip of the schists, and that sometimes the schists appear to be permeated throughout with the ore. Adopting this view for the moment, the following supposition would appear to afford a possible explanation of most of the phenomena with regard to the ore, which have as yet been observed. With the original materials of the sandstones and mudstone shales, which subsequently become metamorphosed into schists, the ore may have been either chemically or mechanically deposited. At some period the crushing and tilting up of the rocks, of which there is abundant evidence, produced cracks and possibly openings between adjacent beds, towards which a segregation of the copper particles which until that time were equally disseminated throughout the mass

of the schists may have taken place and continued until they became filled with ore and so given rise to the appearances which have been regarded as indicating the existence of lodes. If this view be correct then the highly metamorphosed rocks which occur in the otherwise uninterrupted strike of schists at Akarsuni and Kumerara must be derived from the schists by excessive local metamorphism. But if, on the other hand, these rocks belong to the older metamorphics which they certainly at first sight appear to do, then the lode hypothesis must be admitted to be true.

Reviewing the evidence on both sides, the legitimate conclusion to be drawn would seem to be that the copper of Singhbhúm in all probability occurs both in lodes and as a deposit disseminated throughout the materials which compose the schists. Similar cases of double conditions of occurrence are not unknown in other countries, as will be alluded to again further on.

ORES.

The ores of the upper part, or, as it is technically called the 'back' of the deposit, have all been converted into carbonates and oxides.

In assays made upon eight different qualities of ore by M. R. Schenck, and quoted in the Hindostan Copper Company's prospectus, the contained copper varies between 35·03 per cent. and 1·46 per cent. Three analyses by Messrs. Phillips and Darlington of specimens of carbonates gave the following results :—

No. 1.—Copper	31·5 per cent.	Silver	2oz.	5dwts.	17grs.	per ton of ore.	
No. 2.— ,,	6·26 ,,	,,	1 ,,	2 ,,	20 ,,	,,	,,
No. 3.— ,,	6·0 ,,	,,	0 ,,	19 ,,	14 ,,	,,	,,

Three other specimens were examined by Messrs. Howard and Dollman and gave the following results :—

No. 1.—18·8 per cent. of copper.
No. 2.—21·8 ,, ,,
No. 3.—24·0 ,, ,,

Three specimens brought by me from Jamjura yielded according to Mr. Tween's analysis—

No. 1.—Jamjura ore, copper	= 52·0 per cent.	
No. 2.— ,, ,,	= 44·5 ,,	
No. 3.—Dugni ,,	= 36·5 ,,	

Nos. 1 and 2 were picked specimens, but No. 3 was the ordinary ore to be found at Dugni.

Messrs. Henry Bath & Sons, to whom some of the ores, smelted to a regulus, were sent in 1854, reported as follows :—" Our assayer has carefully tested the samples thou sent us; they contain about 50 per cent. of iron which makes them very difficult to smelt, and is also very prejudicial to their sale; we think, however, that the prices affixed to them may be obtained."

We are thy sincere friends,

HENRY BATH & SONS.*

Mining Office, Swansea, 8*mo*., 19, 1854.

No. 1.—Copper,	42 per cent.	£37	per 21 cwt.
No. 2.— ,,	41 ,,	35-15	,, ,, ,,
No. 3.— ,,	39 ,,	34-2	,, ,, ,,
No. 4.— ,,	36 ,,	31	,, ,, ,,

The assays above quoted were of the carbonates or of grey-copper.

Copper pyrites occurs in the schists at Rajdoha; it was first found there by the second company; fragments of rock permeated with it are still to be found in the debris. It seems to have been little affected by the weather.

* Proceedings Asiatic Society of Bengal, XXIV, 1855, p. 706.

NOTE.—Of the minerals occurring in the schists, the following are the principal which have been met with: Garnet, Schorl, Kyanite, Chlorite, Tremolite, and Actinolite. In the hill Dari, which is formed of potstone underlying the schists, a peculiar indurated talc occurs in veins. The potstones are extensively quarried, and supply a plate factory in the neighbouring village. At Jamjura M. Stœhr discovered an interesting carbonaceous mineral, of which I also obtained specimens in the refuse heaps when I visited that locality; it is described in the Mining and Metallurgical Journal for 3rd June 1859.


Chaibasa
Kankar Beds
Calcareous Schists
Amita
Ghatsila
Dhadkai
Hartopa
Dompori
Kumarsa
GEOLOGICAL COLORS & SIGNS
Trap
Dips & Strikes
Scale 1 Inch = 8 Miles

Some of the manufactured copper was thus reported on at the Calcutta Mint:—

"Three slabs weighing about 139 lbs.; these were subjected to lamination and proved to be suited in all respects for purposes of coinage. The quality of this metal is excellent, being scarcely inferior to the best, equal to the average and decidedly superior to several shipments of imported copper."

(Sd.) R. BAIRD SMITH,
Mint Master.

As it is almost impossible at the present day, without excavating in the mines to a considerable depth, to obtain more than a few specimens of the carbonates or oxides of copper which lie near the surface or incrust the walls of the galleries, it is most fortunate that we are able to avail ourselves of M. Stœhr's researches and opinions. His presence during the mining operations and subsequent examination of the ores in Europe have afforded him the most favorable opportunities for ascertaining the precise nature of the ores obtainable in the deep mines.

It may be taken as a fact fully established by the analyses quoted above, that exceedingly rich ores of copper do occur in Singhbhúm. Before proceeding to the discussion of the practical question in reference to the possibility of working the ore with profit, it is necessary to allude to the—

METALS IN ASSOCIATION WITH THE COPPER.

It is a matter of the greatest importance to ascertain the proportion of other metals which ordinarily occur associated with the copper. Supposing the ore even not to contain a sufficient quantity of copper to make it pay to extract it alone, it might still, if it included precious metals, be worked with profit. Such is the case with the argentiferous ore or Fahlerz from Eisleben in Prussian Saxony.

In the assays of three specimens of ore by Messrs. Phillips and Darlington quoted above, the ounces of silver per ton of ore vary between 1 and $2\frac{1}{4}$. M. Stœhr found traces, but only traces, of gold and silver; while Mr. Tween did not obtain even a trace in some ores and smelted copper which I brought from Jamjura.

Small quantities of Bismuth were found in some of the ores.

Having in the previous pages pointed out the two-fold manner in which the copper ores occur—both in lodes and in beds—and their quality, the discussion of the practical question whether the ores are such as can be worked with profit in this country may now be entered upon. The facts and collateral circumstances which must influence a decision may be grouped under the following heads:—

I. Character of the ores and their mode of occurrence.

II. Experience of previous miners, ancient and modern.

III. Local circumstances.—Position of mines; Means of communication and distance of marts; Supplies of labor, fuel and lime; Proprietory; Climate.

IV. Comparison with other countries where ores of similar character and occurring in a similar manner have been worked.

I. Although rich ores exist, their mode of occurrence is so capricious and uncertain that working them must necessarily involve an enormous expenditure.

Ores of very much inferior quality if they occurred with a continuous unbroken lead which could steadily be followed up by the miners might, even under various unfavorable conditions existing in Singhbhúm, be worked with profit.

M. Stœhr distinctly speaks of good ore having been found at many points, but in nearly all cases an unusual richness of the deposit proved to be purely local and confined to nests which were speedily worked out, and unremunerative copper-permeated schist met with further down.

II. Many of the ancient mines have been so thoroughly worked out that it is often impossible to find more than mere particles of carbonate incrustations.

It may be argued with an apparent amount of plausibility that the ancient mines, their number and extent, indicate a prosperous condition of the industry at some former period. We do not, however, know under what circumstances they were worked. In the early times to which they seem chiefly to belong, copper may have possessed a value relative to the precious metals much higher than it does at present. And, again, although it may have paid parties of natives to work with their simple furnaces which could without loss be relinquished when the supply of ore failed and others be erected in a new locality, we cannot feel assured that it would prove proportionally profitable to a European Company, whose chief prospect of success would depend on the possibility of applying machinery for the extraction and reduction of the ore continuously in one place.

With regard to the experience gained by the companies, beyond M. Stœhr's and M. Durrschmidt's papers, there seems to be now no accessible information. Without being able to refer to the records of either of the companies, it is impossible to form any estimate of what their working expenses amounted to.

Copper was manufactured during the time of the second company and forwarded to Calcutta, but what proportion its price in the market bore to the cost of its production I have been unable to ascertain.

M. Stœhr's opinions on the first company and on the proposition to form a second are printed herewith. He concludes that notwithstanding the disadvantages, some of the old mines might be worked profitably, but for that purpose so colossal a company* was not suited. But *moderate expectations*, such as M. Stœhr speaks of, are not generally sufficient to attract speculators and capitalists; and a really economical enterprise such as might easily be carried out on the continent of Europe is scarcely practicable here.

III.—Local circumstances.—*Position of Mines.* On all sides the range in which the copper ores occur is surrounded by broken hilly country, which is drained by a number of rivers of sufficient dimensions to seriously impede traffic during the rainy season.

The only made road in the vicinity of the mines is the one between Chaibassa and Midnapur. It is unprovided with bridges: the portion of it in Singhbhúm and Dhalbhúm alone is (May 1869) in fair condition.

In reference to the roads, Colonel Haughton, who was anxious to represent the prospects of a mining enterprise in the most favorable light possible, wrote:—"From the diggings at Kumerara† there is a good road only 85 miles in length to Tumlook. The distance "from Landu or Jamjura to the Cossye river at Dhee Kulliánpúr is about 70 miles; and that "river might, it seems probable, be available for water carriage during short periods in the "rains, as the Damúda is at points far above those where it is ordinarily navigable. There "is every facility for the construction of a good road to Dhee Kulliánpúr or to Midnapur, "and in fact there was formerly a Government route in nearly the same direction. * * * "The distance from Tumlook *viâ* Midnapur would be about 132 miles." The copper which was made in 1862-64 was not despatched by either of these routes but *viâ* Purulia to Raniganj, the distance of which place from Landu being 130 miles, and the roads little better than cart tracks.

Should the proposed direct line of railway *viâ* Midnapur to Bombay be opened up, the copper mines will probably be rendered much more accessible than they are at present.

Labour.—Coolies can be obtained in abundance. The Chota Nagpur Dhangas were found to be the best workmen.

Fuel.—The supply of wood to be obtained in the immediate neighbourhood is limited. and a few years would exhaust the timber on the hills composed of the copper-bearing rocks. There is, however, a considerable amount of heavy timber on the rises to the Chota Nagpur plateau.

The discovery of coal at Midnapur is a fact which may prove favorable to the prospects of working the copper with profit.

Lime.—The only lime which was used for fluxing the ore was manufactured from 'kunkur.' No hope of any more regular or economical source can be held out at present. Some calcareous schists do, indeed, exist near Chaibassa, but in them the quantity of other minerals mixed up with the carbonate of lime is so great as to make it doubtful whether they could be successfully burnt for lime.

* The capital of the 2nd or Hindostan Copper Company was £120,000 in 24,000 shares.
† The most eastern locality.

Proprietory.—Singhbhúm proper belongs to several members of the Porahat family, of whom the principal are the Koer of Seraikela and the Thakúr of Khursowa; they both give service to Government as Magistrates, but pay no tribute whatever for their estates. The Dugni Baboo in whose lands copper also occurs is a cadet of the same family.

In the estate of the Rajah of Dhálbhúm, the remainder of the copper localities, including those at Landu and Rajdoha, are situated.

The first company, confident in the productiveness of the mines, agreed according to M. Stœhr to pay the Rajahs of Seraikela and Dhalbhúm Rs. 9,200 for the right to mine. In the prospectus of the second company the annual rent is stated to be Rs. 4,500. A considerable portion of this rent for the years while operations were being carried on is still due. Acting on a decree of the Singhbhúm Deputy Commissioner, the Rajah of Dhalbhúm has seized the houses and engine of the company at Rajdoha; but the former have already fallen to pieces, and the latter uncared for and neglected will soon become worthless.

Climate.—The climate of Singhbhúm is decidedly unhealthy; this point is one of no small importance where a number of Europeans might have to be employed. I have been informed that the employés of the two copper companies suffered much from fever. My own experience is, that natives of India, especially men from the north-west, suffer excessively from fever in Singhbhúm; of course both Europeans and natives might, to a certain extent, become acclimatized, as has happened in other parts of India.

IV.—Examples are not wanting in other parts of the world where ores of similar character and mode of occurrence to those of Singhbhúm have been worked, with which a brief comparison may be usefully instituted.

Copper Mines of Eisleben.—At Eisleben in Mansfeld, Prussian Saxony, the ore of copper extracted permeates a schist (Kupferschiefer) which can be worked with as much regularity as a coal seam.* Notwithstanding the perfection of the machinery and the comparative ease with which the ore is extracted, it is a fact that the copper is manufactured at a loss. "Every ton of refined copper as it leaves the works has actually cost more than an equal weight of metal could be purchased for on the spot from the merchant."

The profits of these great and unique mines (which more or less directly support 60,000 people) are nearly all derived from the small proportion of silver which occurs in the ores and is extracted during the process at but little additional cost. The magnitude of the operations and the immense quantities of the copper ore which are smelted alone enable the work to be carried on with profit.

In the copper ores of Singhbhúm silver does sometimes occur as is shown by the assays on page 96. But the amount is so small that it is extremely doubtful whether it could be extracted with profit.

It has been stated that *for the most part* the underlie of the ores in Singhbhúm corresponds with the dip of the schists; but it can scarcely be said of them, owing to their steep inclination and irregular lateral extension, that they could be 'worked like a coal seam.'

South-West of Ireland.—In the south and south-west of Ireland copper ores occur disseminated throughout a zone of Devonian sandstones; for a long time it was doubted whether true metalliferous lodes existed, all the copper being supposed to occur "as a mechanical deposit derived from the waste and destruction of some original mineral vein district."† Recent deep mining operations which have been carried on with success have proved the existence of true lodes.‡ Thus there would appear to be a double mode of occurrence of the ore there, similar to that which has been supposed to be the case in Singhbhúm.

In the preceding pages the object sought after has been to give a simple statement of facts, from which those who may be interested will doubtless draw their own conclusions.

In mining operations such as would be necessary in Singhbhúm so much depends upon the regularity with which the ore occurs that no one could with any confidence venture to predict the result of excavation on a large scale.

Courageous enterprise guided by the best professional skill in mining has both its triumphant successes and its heavy losses and disappointments: until underground exploration has extended much further in Singhbhúm, it will be uncertain which fate awaits those who may at any future time venture upon copper mining in that district.

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* These mines are fully described in a paper by Mr. Jervis, Jour. Soc., Arts, vol. IX, 1860-61.
† Memoirs of Geological Survey of Great Britain and Ireland, explanations to sheets 200, 203, and pp. 278.
‡ Geological Magazine, vol. VII, No. 5, p. 241.

COPPER ORES

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhûm.	1	Madhopur, 3 miles north of Kumerara.	2	Outcrop excavations ...	......
	2	Hills, W. of Asunbuni	Numerous ...	Ditto ...	40° E. N. E.
	3	Hills, S. E. of Badia	......	......	......
	4	Badia	Very numerous ...	Ditto and shafts ...	40° to E. 25° N.
	5	Mosabuni	Numerous ...	Outcrop excavations ...	Ditto ...
	6	Surda	12	Ditto ..	?
	7	Hills, W. & W. N. W. of Surda ...	Numerous ...	Quarries, shafts, inclines	40°
	8	Hills, W. of Teringa & Kendadih ...	Ditto ...	Outcrop excavations & inclines.	30°-35° E. N. E.
	9	Sideshur Hill, S. of Ruam... ...	3 or 4	Ditto & shafts ...	35° N. E.
	10	Mahadeo Hill	......	......	......
	11	Baghghura	Several ...	Inclines ..	......
	12	Hills, S. & S. W. of Matigara (=Raga of Dr. Stœhr).	Numerous ...	Ditto & shafts ...	N. E.
	13	Rangamatti Hill, S. E. corner, N. of Banjo.	1	Shaft	.
	14	Rajdoha a	1	Incline and adit	
		Ditto b	1	Incline	25° N. N. E.
		Ditto c	1	Shaft .	Ditto ..
		Ditto d	1	Incline	Ditto ...
	15	Matku	1	Shaft	.....
	16	Hurtopa...	1	Ditto	.....
	17	Hitku	1	Ditto	....
	18	Landu Barut-ghur Hill	Numerous ...	Shafts, inclines, adit, trench.	35°—, 55° to 10° E. of N.

OF SINGHBHÚM.

No.	Ore.	Rock.	Remarks.
1	Traces of carbonate: a specimen yielded according to Col. Haughton 24¾ p. c. of copper.	Quartz and black mica-schist, strike 10° E. of N., granite close by.	These mines are full of water, to remove which and renew excavation would be necessary before the condition of the ore could be ascertained.
2	No traces of ore *in situ* ...	Black and grey mica-schists ...	Slag close by, indicating that ore was once found.
3	......	......	This locality is given by M. Stœhr.
4	Traces of carbonates abundant.	Grey and black mica-schists, strike 25° W. of N. Towards Mosabuni gneissose rocks strike more to north.	The relative positions of the Badia excavations indicate four distinct outcrops of ore. The principal of these passes through the village of Badia, near which are great heaps of slag. This was evidently a centre of extensive operations.
5	Ditto.		
6	No trace of ore at present exposed.	Schists.	
7	Incrustations of the carbonates on the walls.	Black mica-schist	From the abundance of slag it would appear that here, as at Badia, considerable quantities of ore must have been smelted by the ancients.
8	Traces of carbonates rare ...	Mica-schist.	
9	Ditto slag abundant ...	Ferruginous mica-schist ...	At the site of the old town of Ruam, there are several tanks covered up by jungle and immense quantities of slag.
10	......	......	This locality is given by M. Stœhr.
11	Ditto ...	Mica-schist.	
12	Ditto ...	Ditto	A number of deserted potstone mines and some which are still worked occur along this range.
13	Traces of carbonates ...	Ditto & quartzite ...	Incrustations of the carbonates and black oxides occur on the quartzites forming the main axis of the hill.
14	Ditto ...	Slaty blue schists	These are situated on a spur of Rangamatti.
	Ditto ...	Ditto ...	These were worked by the Copper Company. But the pyrites was only just reached a short time before working was discontinued; d is west of the river, b and c being to the east.
	Copper pyrites	Ditto ...	
	Traces of carbonates ..	Ditto ...	
15	Carbonates, traces of red copper and pyrites.	Greenish talcose schist and quartzo-felspathic grit.	
16	No ore seen	Quartzite.	
17	Traces of carbonates ..	Schist and quartzite	Originally commenced by the ancients; it was deepened by the Company, but has subsequently become filled up.
18	Ditto ...	Quartz and mica-schist much contorted and baked. Banded jaspery quartzites close by.	A considerable amount of ore appears to have been obtained here by the Company. M. Stœhr's papers give the details of workings carried on at Landu.

COPPER ORES OF

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhúm.		Landu Chundra Hill b	Numerous ...	Inclines	35°, 55° to 10° E. of N.
		Ditto Hill, N. of Turamdih c	Ditto ..	Ditto	40°—50° N., or 10° E. of N.
		Ditto Hill, N. of Tulsa d ...	Ditto ...	Ditto and adit ...	40° N.
Kocr of Seraikela.	19	Jeling { gora ... ... / bera ... ... }	2	Shaft and incline ...	?
	20	Jamjura (*Tschamtschura* of M. Stœhr)	Several ..	Shafts ...	......
	21	Gura	0	....	......
	22	Tamba—dungri	6 ?	Shafts	25 N.
	23	Saldih	1	Ditto	N. N. W. 50°
	24	Múndrú	1	... .	N. N. E. 40°
	25	Dúgni	0	0	60° N.
	26	Ukri	1	Outcrop excavation ...	,,
	27	Komulpur (Banksai)	1	Ditto ...	?
Thakúr of Khursowa.	28	Akarsúni a	Several	Ditto .	N. W.
		,, b	1	Ditto .	?
	29	Podumpur	2	Ditto .	?
	30	Regadih	4 (a-d) ...	Ditto .	?
	31	Lopso Hill	1	Ditto	40° N.

SINGHBHÚM,—(Continued).

No.	Ore.	Rock.	Remarks.
	Traces of carbonates ...	Schist.	
	Ditto ...	Contorted talcose quartzite and micaceous schists.	These works were chiefly made by the Company, but all along the outcrop of the schists there are ancient excavations. In one place the ore permeates 6' of rock.
	Ditto ...	Ditto ...	The mines here were worked by the Company.
19	Ditto ...	Talcose and mica-schist.	
20	Ditto and grey copper.	... .	These shafts were worked by the Company; one of them fell in while the operations were going on.
21	Traces of carbonates ...	Schist	No mines opened at this locality.
22	Ditto ...	Sandy and fibrous mica-schists	Shafts in very irregular positions and without reference to the lie of the deposit.
23	No trace of ore ..	Mica-schists.	
24	Ditto ...	Soft satiny felspathic and talcose schist.	Said to have been excavated by the father of the present Baboo of Dugni, Rungit Singh.
25	Traces of carbonates ..	Mica-schists	This is situated in the village of Dugni; there has never been any excavation.
26	Ditto abundant, a specimen yielded 36·5 per cent. of copper.	White talcose mica-schists and granitic gneisses.	Said to have been worked with profit by the Dugni Baboo about three years ago.
27	Ditto ..	Schists and gneiss.	
28	Traces of carbonate	Schists, granitic gneiss and trap close by.	A series of excavations in the fields are nearly filled up with surface soil.
	Ditto ..	Ditto.	
29	Ditto .	Mica-schists and quartz . .	Rocks much covered; no strike apparent.
30	Ditto ...	Micaceous and quartzose schists, also gneiss and trap close by (c).	Copper is said to have been manufactured from ore extracted from (d) twelve years ago.
31	Ditto ..	Coarse mica-schists	Situated at foot of the hill west of Kaurudih.

V. BALL,
Geological Survey of India.

METEORITES.—During the past quarter we have received an addition of four specimens of meteorites, representing 3 falls, of which no specimens existed in the Calcutta collections previously.

1st.—From DR. TSCHERMÁK, the present zealous Director of the Mineral Cabinet at Vienna, came a very perfect, though not large, specimen of the fall at Hessle, near Upsala, which took place on the 1st of January 1869. And a very good specimen of the remarkable stone-fall which took place at Kernouve, Napoleonville, Morbihan, France, on the 23rd May 1869. 2ndly, from PROFESSOR DAUBREE, Paris, we have received a fine specimen of the meteoric iron from Deesa, Chili, peculiarly interesting, not only for the breccia-form structure which it presents (recalling the Tula fall), but for the occurrence in it of very well marked crystals of *Enstatite, colourless and transparent* and of a purity not hitherto met with, also crystals of *Peridot*, of *Schreibersite*, and of a lamellar substance closely allied to *Hypersthene*. And also a second smaller specimen of the Kernouve (or Cleguerec) fall of the 23rd May 1869. These were all in exchange for specimens of Indian falls.

T. O.

DONATIONS TO MUSEUM.

From COLONEL H. C. JOHNSTONE we have received a box of fossils collected by him in the Sulyman Range. There has not been time as yet to examine these in detail.

ACCESSIONS TO LIBRARY

FROM 1ST JULY TO 30TH SEPTEMBER 1870.

Titles of Books. *Donors.*

ANDRÆ, DR. CARL JUSTUS.—Vorwerltliche Pflanzen, 2nd Heft. 4to., 1869, Bonn.

BERENDT, DR. G.—Geologie des Kurischen Haffen und seiner Umgebung, 4to., 1869, Königsberg.

BIGSBY, JOHN J.—Flora and Faunna of Silurian Period *(Thesaurus Siluricus)*, 4to., 1868, London.

BENEDEN, VAN, AND GERVAIS, PAUL.—Osteographie des Cétacés Vivants et Fossiles, Livn. 8, 8vo., and Atlas, 4to., Paris.

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OF

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VOL. IV.

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THOMAS OLDHAM, LL.D., F.R.S.,

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RECORDS

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GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1871. [February.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1870.

Since the publication of the last annual report, the year now just passed has enabled the Geological Survey of India to make considerable progress in the careful examination of the country.

Taking the several districts in succession, I shall briefly refer to the progress made in each.

In the first place, it is necessary to notice the numbers with which the survey has been carrying on its labors, as the area which can be examined very seriously depends upon this. The vacancy in our staff caused by the lamented death of Mr. C. Æ. Oldham in 1869 had not been filled up, as no qualified person could be obtained at the time. And the absence on leave of Messrs. King and Mallet, neither of whom returned till just at the close of the year, left the staff of the survey diminished by three of its most qualified members for the whole twelve-months. Early in the season also, Mr. Ormsby, who in the previous year had been obliged to proceed to Europe in consequence of the effects of sunstroke, but had returned apparently restored, again felt the serious effects of exposure, and was obliged to leave the field rather earlier than usual. He was able to do some work in office, but gradually sank and succumbed to the effects of the attack and exposure in June last. Since March also, Mr. Fryar, specially sent out for the compilation of the mineralogical statistics of the country, has been placed under the orders of the Central Provinces Government for mining purposes, and has not in any way contributed to the progress of the Geological Survey. We have thus in reality been working during the year with only three-fourths of the full sanctioned numbers on the staff of the survey. Mr. King was obliged to seek extension of leave from ill-health in England, and Mr. Mallet was authorized to proceed on special duty counting three months as service, in addition to his furlough. Thus, neither of these gentlemen was back until quite the end of the year. Dr. W. Waagen joined the survey, to fill the vacancy in our numbers caused by the death of Mr. Oldham in 1869, about the middle of December, and has since then been most zealously engaged in the preparation and examination of the fine collection of *Cephalopoda* made during the last two years in Kutch.

It has been my duty on many occasions to point out the great delay and loss of work which result from such changes in the staff. There is no source in this country from which properly qualified assistants can be obtained for the Geological Survey. In truth, Geology is nowhere taught in this country, and assistants must be sought for in Europe, where such sciences are cultivated. The numbers, however, from which they can be selected are small. Those who have proved themselves competent readily and rapidly find employment at home, where the terms of retiring allowances and of pay are much more favorable, under the circumstances, than are offered out here. And it is only possible occasionally to procure the

aid of really trained and qualified assistants, who, either from a desire to see the geology of countries they could not otherwise hope to be able to visit, or from other causes, will venture to face the difficulties, hardships, and perils of a geologist's life in this country. Such a description may appear to some highly coloured, and that geologists have no more reason than others to be anxious on the score of health. I have, however, often had occasion to point out some of the causes of this—that geologists are compelled not only to visit for an hour or two, but often to remain camped for days in the very wildest, most inaccessible, and most inhospitable parts of the country. These are precisely the places most likely to afford them sections, and thus to give a clue to the structure of the district; but they are also the most dangerous. The serious losses which the survey has experienced since its commencement amply prove the truth of this. But perhaps the most convincing proof, that we are not alone in this view, will be to quote the deliberate opinion of Assurance Offices, who have had the whole facts carefully enquired into by their medical officers, and who acknowledging that there is no objection on any other ground to accept insurances on the lives of officers of the survey offered to them, yet decline to do so, stating that "no premium whatever would cover the risk."

And, further, when new assistants have been obtained, a considerable time elapses before they acquire a knowledge of the languages of the country and an acquaintance with the peculiar arrangements necessary for tent-life and marching in this country, so that they must necessarily be for some time placed along with others, and cannot work independently.

Mr. H. B. Medlicott, Deputy Superintendent, devoted the early part of last year to the careful and detailed examination of the country near Mopani, the site of the Narbadda Coal and Iron Company's collieries. When this area was originally visited and mapped out (in 1856-57) there were no maps whatever on which to record the observations of the survey. A general compass-sketch was very successfully carried out by Mr. J. G. Medlicott, then engaged there, and on this, on the scale of four miles equal one inch, the structure of the country geologically was represented and published (Mem., Geol. Surv., India, Vol. II). No one could be more fully aware of the imperfections of this sketch than those who constructed it; and we, therefore, looked forward anxiously to the completion of the detailed and careful maps of the regular survey. The operations of the revenue survey under Colonel J. E. Gastrell had been extended to that part of the country, and at the close of 1869 we were enabled, by his kindness, to obtain maps of part of the district, even in anticipation of their publication. These were just sufficient to enable us to take up the re-examination of the field, which the progress of railway communication, the opening out of the line in the Narbadda valley, and the general increase in the demand for fuel, rendered so immediately important. This re-examination Mr. Medlicott personally commenced, and the results, so far as the Mopani field is concerned, have already been published (Records, Geol. Surv. of India, Vol. III, August 1870). It is intended to carry on the careful examination of all the country which affords the least prospect of yielding coal or other valuable minerals in that neighbourhood as the detailed topographical maps become available.

At the commencement of the present working season, Mr. Medlicott took up the revision of the geological maps of the Jhansi, Lullutpur, and Saugor districts, prepared by Mr. Willson and others, with a view to their publication. Completing this, Mr. Medlicott will return to the Narbadda valley.

Mr. W. L. Willson has been engaged during the whole of the year, and still is engaged in completing the examination of the country just referred to, and extending northwards to the Jumna, by Calpi.

Mr. Hacket has been examining the Jabalpur country, with the advantage of the recently completed detailed maps to record his observations, and I hope the present season will see this district completed.

Mr. Ball, as stated in last year's report, was deputed to revise the maps of the Rajmahal hills, which are now ready for publication, so soon as the copper plates of the sheets of the Indian Atlas can be obtained from England and the maps transferred to stone for the geological lines. In the present season Mr. Ball has proceeded to the south of the Chota Nágpúr country and Sirgujah, with a view to determine, at least approximately, the boundaries of the extensive spread of coal-bearing rocks which there occur. For a large portion of this country maps are now for the first season available. But there are still important gaps, for the plans of which we shall have to wait for some time. Still it is hoped that we will be able to fix the boundaries with, at least, approximate accuracy over a very considerable area. Progress in these districts is unavoidably slower than elsewhere. Much of the country is without a road at all, and much of it is accessible only with elephants.

In the early portion of the year, Mr. Ormsby had completed the revision of a large portion of the Bhaugulpore country. But his illness, and lamented death, prevented the final completion of the maps of that area.

Mr. Mallet, who rejoined the survey towards the end of the year, has resumed the area on which he was last engaged, *viz.*, the southern parts of Mirzapúr and the adjoining parts of Rewah, &c., in the same valley. These are said to be rich in mineral wealth; and we are now for the first time able to take advantage of the recently completed maps of Rewah, &c., and to use them as records for the geological observations. Mr. Mallet had, on his return from Europe, been ordered to stop at Aden, and examine Aden and the country lying to the north of it between the peninsula and the hills with a special view to determine whether the principle of Artesian wells could be applied there with any prospect of success, in order to increase the supply of good water to the cantonments. Mr. Mallet's report on the geological structure of this country will shortly appear in the Memoirs of the Survey.

In Madras, by the absence of Mr. King and the death of Mr. Oldham, the party of the survey was reduced to only one, Mr. Foote. He completed the geological mapping of a considerable area of country, stretching along the valley of the Upper Kistna and adjoining area. Here the chief object has at present been to determine, on the one side, the outline of the great Deccan trap rocks, which have overflowed all the earlier formations, and cover them with a thick and nearly continuous spread of old volcanic lavas and muds, and, on the other hand, to fix also the general boundary of the immense area of fundamental gneissic rocks which constitute the basement rocks of everything else. Between these two, various other series crop out irregularly, and it is important to determine what these may be. This is the position which the coal-bearing rocks of India, among others, occupy, and there seem no sufficient reasons, *a priori*, why detached portions of these should not occur along the boundary in its south-western corner, as well as on the north-eastern. Hitherto no trace of them has been found, but, of course, we can only speak with any certainty regarding that portion which has been examined. Mr. King, who has recently returned from leave, has now rejoined the Madras party, and has taken up the continuation of the same boundary lines to the north by east, and will, I trust, during the present season, be able to carry his geological examination at least as far as Koolburga, while Mr. Foote will more especially extend his enquiries by the south and west to the Belgaum area, so as to join his lines with those already mapped some years since by Mr. Wilkinson in the Kōkan and southwards to Goa.

At the commencement of the year, Mr. W. T. Blanford was actively engaged in the detailed examination of the Berars and of Chanda district, and had nearly completed the portions of the Berars lying north of the Pem or Pein river. He was then specially diverted from this to visit and obtain a general idea of the extent and value of the coal-fields which had been for more than thirty years known to exist in Bilaspur, near Korba, &c. No topographical maps of this country, excepting in small detached areas, had been published up to date, and a detailed examination was, therefore, impracticable. I believe it was the late Colonel Ouseley

who first announced the existence of coal near this place, (as 'discovered March 14th, 1840,') and the fact had been noticed in all maps issued subsequently. The place had also been visited by several Forest Department Officers and others, and it was well known that coal was visible in detached localities extending over a considerable area. And although not having survey maps to work with, the Geological Department could not, in obedience to the instructions they had received, take up the examination in detail, it was highly desirable to obtain a general idea, with some accuracy, of the extent and probable richness of these coal-fields. The vast importance of these fields, whenever a direct line of railway to connect Bombay and Calcutta might be brought into operation, had more than once been insisted on by myself and been most strongly urged. Mr. Blanford, therefore, proceeded there, and the results of his general examination have already been published. It is needless to enter here on the details, which will be found in the May number of the Records of Geological Survey of India, 1870. It will suffice to say that Mr. Blanford satisfied himself of the existence of very thick and extensive beds of coal, yielding fuel of fair quality in abundance, and covering a large area. He also traced out the continuance of the same rocks with coal far to the eastward, and in the country lying between Korba and Ranchi, in Oodeypore (Udipúr), Jushpúr, &c.

Mr. Blanford was also requested to take advantage of his being in that vicinity to examine the lead vein, reported, by Mr. Smart of the Revenue Survey, as occurring at Chicholi near Raipur. This would appear to hold out promise of being valuable. At least there is nothing in the appearances inconsistent with the occurrence of a good vein of lead and copper ore below the surface. But as the place has not been opened out, and no works have as yet been undertaken on the lode, it is impossible to determine accurately its value from surface examination (Records, Geol. Surv., India, 1870, pt. 2, p. 44). The yield of silver in the lead ore proved equal to 9 oz. 19 dwts. to the ton of lead. All this country is, however, at present so difficult of access and so entirely without the means of free inter-communication with adjoining districts that no extensive works for the economizing of these valuable mineral products could be undertaken with any prospect of success. There is an immense area here of country very rich both agriculturally and mineralogically which must remain unimproved until its communications be extended, and it be brought into contact with the ports of shipment and the more populous territories lying both east and west of it.

Mr. Hughes was, during the whole of the early part of the year, engaged in the careful examination of the coal-bearing rocks of East Berar and Chanda, and is still carrying out the same. After I had myself left these fields at the beginning of March, I entrusted the sole determination of the proper localities for boring operations in the Berars to Mr. Hughes, and with the aid of Mr. Bateman Smythe, who had the actual work under his control, most successful progress was made in tracing out the continuous extension of the thick beds of coal up close to the northern extremity of the East Berar district. The monsoon having put a stop to these borings for a time, as there was nowhere in the district where good shelter could be procured, the tools, &c., were all removed to Yeotmahal, all repaired and rendered useful again. And on the opening of the season, Mr. Smythe at once commenced other borings, and found the coal at or near the village of Pepra or Pipar in the north-west of the field, and subsequently near to the river Wurdha, close by the village of Suini, or Sewnee, which lies west by north of the town of Wurrora, about seven miles. This is the most northerly point at which the coal has been as yet proved in these fields. It is in a right line not more than 35 or 36 miles from the station of Wurdha, on the Great Indian Peninsula Railway. Under Mr. Hughes' direction, Mr. Smythe, having thus carried up the coal to the extreme north limit of the Berars at this part of the boundary, has since commenced testing the extension of the coal more to the west, and with a view to prove whether it continues under the overlying trap rocks, has commenced boring to the west and north of the former sinkings.

The continuance in almost unbroken extension and in thick beds, at no point more than 70 yards from the surface, of coal, easily accessible, and abundant throughout almost the entire length of the Wun district in East Berar along the valley of the Wurdha, has been thoroughly established by the Geological Survey in a portion of one season's work. Not a single boring has failed under Mr. Smythe's charge, or Mr. Heppel's, while so engaged. And sufficient is now known to justify the actual commencement of sinkings and establishment of collieries with a certainty that they can be conveniently placed for working. Mr. Hughes has shown much judgment and skill in fixing the localities for these borings since I left, and has been very successful in working out the geology of the district.

Mr. Fedden, during the same time, was mapping in the area covered by the trap rocks to the north, north-west, and west of the coal-field, so as to fix accurately their boundaries in the vicinity of the coal-measures. There is a very large area to the north which has not been yet visited. And this work is being continued in the present season.

More recently the recurrence of the coal-bearing rocks to the north of the area covered by the outlying portion of these great trappean flows near to Wurrora has been pointed out by Mr. Fedden and at once communicated to the Central Provinces Government, so that trial borings may be carried out in that locality. It is near Khandalla, a village about $5\frac{1}{2}$ miles nearly due north of Wurrora. This area had escaped the notice of the party who have been boring all the season close to Wurrora town.

In the number of these Records for May 1870, I gave a brief sketch of the knowledge which had then been obtained of the structure of the coal-fields in that part of the country. Since then there has only been little more than a month's work, so that there has not been much addition to this knowledge. At the close of last April also, I am happy to say the charge of the actual trials and borings within the area of the Chanda district was transferred to the Government of the Central Provinces, and for any explorations made in that area since then the Geological Survey is not responsible. Before leaving the field for the monsoon recess, Mr. Hughes pointed out a proper locality for boring near the town of Wurrora, south of the trap rocks already spoken of, and coal has been found near there. I had also stated in the report alluded to, (Records, Geological Survey, India, 1870, No. II, p. 43,) that a boring would probably be required in the vicinity of that town. I am informed that some fourteen or sixteen borings have been undertaken there, and that coal has been proved in three or four. It proves to be, exactly as was anticipated, irregular and less abundant than in the adjoining territories.

As there would seem to have been some misapprehension as to our views, arising from a hasty reading of the expressions in the report referred to, it may be well here to refer again to the statements made. In calculating the area under which coal could fairly be estimated to extend, the portion of the district covered by the thick flows of the trappean or volcanic rocks was rejected from any present consideration, because it was said, "this "thickness of trappean rocks effectually conceals everything beneath them, and, looking to "the great irregularity with which the coal rocks are overlapped, and the impossibility of draw- "ing any sound conclusion either as to the place or depth below the surface at which coal might "be found, fully justifies our putting the entire of this area out of calculation in estimating "the extent or quantity of the coal in these Wurdha-river fields. A boring will be put down "to the north of this large area of trappean rocks, where the lower beds are again visible "over a small area near Panjoorni, a village about six miles north-west of Wurrora, and pro- "bably near Wurrora itself," (that is, to the south of the same area). "But with this exception, "there will be little use in testing the rocks further on that part of the field *at present.* It "is not at all intended to assert that the coal group does not extend under a considerable "part of this area, but if it does so extend, the chances of finding it are so uncertain, and "the depth at which it probably occurs so doubtful, and in any case so much greater than in

"adjoining areas, that *for the present* at least the coal, even if found, could not be worked "to the same advantage or economy as elsewhere." Nothing can be clearer than that it was anticipated that coal would be found near Wurrora to the south of this area of trappean rocks, and again possibly near Panjoorni to the north of the same area.

It is the more necessary to point these facts out, because geological maps of this part of the country have been published since then in public documents which entirely misrepresent the true state of the case, but for which the Geological Survey Department is in no way responsible. This area of trappean rocks, which is most obviously an outlying or separated portion of the immense extent of overflowing volcanic rocks, which cover some thousands of square miles of the Deccan, and close to the general boundary of which this area lies, is stated to be of "trap rocks coming up through the sandstone" in one case* and is represented as a "trap dyke" in another.† Any geologist will at once see the vastly important difference in the two views here alluded to. In the one there is not only a chance, but almost a certainty, that the coal will be found under a part at least of the area covered at the surface by these rocks, (though we still think this may better be put out of any calculation for the present,) while, in the other, everything would be cut off, and there would be no prospects of proving the extension of the coal-bearing rocks at all. The same maps, which are issued in a way that might lead to the supposition that they had been furnished by the Geological Survey of India, represent the structure of the country very erroneously more to the south. I am not aware of anything to justify the extension of the Tálchír rocks in a broad belt across the entire field up to the crystalline boundary on the east, and I believe there is no foundation for this representation. Certainly no such idea is held by the Geological Department, which is in the same paper stated to have been working out the structure of the field, and which might, therefore, be supposed to hold the views represented on these maps.

It had been my intention to prove the detached areas of sandstones near to Nágpúr during the past season. This could have been done without interfering with the real progress of other enquiries. I am not aware that anything has been done in this direction.

In the report referred to on the 'Wurdha river coal-fields,' I pointed out that so far as information had been obtained up to that date, there appeared to be no question that any line of railway to these fields, if laid out with the object of commanding the widest area and largest amount of traffic for a given outlay, ought certainly to be carried into the Berar country. And there has been nothing since discovered tending in any way to modify this opinion. There is coal, and enough to supply the demand, in the Chanda district. But it is neither so conveniently placed, nor so continuous, nor so economically workable, as in the Berar district. While the latter has the very great collateral advantage of opening out one of the richest cotton districts in India, whereas there is little or no cotton, comparatively, in Chanda, and the nature of the soil precludes any hope of much extension of its cultivation. It would certainly appear an *almost necessary* consequence of the geological structure of the country, that any line, intended to accommodate the largest amount of traffic in these two staples—coal and cotton—*must* be carried on the right bank of the Wurdha river, at least south of the junction of the river Wunna. Any tonnage of coal likely to be required from these fields would be common to either line, while the very large cotton trade of the rich districts of Berar, Edlabad, and all to the south, can only be accommodated to any useful extent by a line passing into, or through, East Berar.

In connection with the examination of these important fields, it is only a matter of justice to the officers of the Geological Survey to point out that, at the first, it was estimated that four years would be required to explore fairly and to determine properly the value of

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* Report of Administration of Central Provinces, 1869-70, p. 70, Map. The workings of the Geological Survey Department have never been, as here stated, under the direction of Mr. M. Fryar.

† Mining Journal, London, October 8, 1870.

the coal-fields, with the full staff sanctioned for the purpose, while not more than one and a half years have already elapsed since a commencement was made. And during even this time those engaged have been diverted to other work. It seems to me not only rash, but positively obstructive, to hurry on to conclusions, which must be as imperfect as the data on which they are based. The topographical maps of all the field are not even yet published, and without these no good geological map can be constructed. Still the greater part, if not all, of East Berar has been examined, and a considerable portion of the west side of Chanda.

But much still remains. And this must just be worked out in the same way, steadily proceeding from the known to the unknown, following up the details of the rocks, and carefully putting together the isolated facts which are visible in this much covered country till the structure of the whole can be built up. It is simply nothing but the wildest speculation to think that you can safely leap to a conclusion, or expect to accomplish in five days or even five minutes what would take more nearly five years to do. Let us apply the consideration to other countries. Any one, no matter how ignorant himself, who would demand a detailed examination, report, borings, &c., of the country between Liverpool and London in a few weeks, would either be pitied as out of his senses, or laughed at as unworthy of a reply from his ignorance. And yet here, if the demand were perhaps met by a simple statement of the impossibility of complying with it, this determination not to attempt what was impracticable would very possibly be thought dilatory.

The discovery of this coal on the Wurdha river is of no recent date. It was publicly made known and exhibited more than forty years since. On the 19th August, in the year 1830, Mr. J. Prinsep, the Secretary to the Asiatic Society of Bengal, laid before the Society a specimen of bituminous coal from the banks of the Wurdha river near Chanda, (Gleanings in Science, Vol. II, p. 386,) and in the next year, Mr. Prinsep gave the results of analysis of this coal, stating then, as we have had to do since, that it contained more than 20 per cent. of ash, and also a larger proportion of volatile matter than usual, which, he adds, might enable the coal, though of little use as a fuel, to be turned to profit for the gas, which it gives out in great abundance (*ibid*, Vol. III, p. 381). This coal has since that time been noticed by several others; it was rejected as not coal at all by many, and it was, in late years, only first declared positively to be good coal by one of the officers of the Geological Survey (Mr. Blanford). A rough sketch outline map was that very season made. But no detailed examination *could* be taken up until the detailed plans were ready. The Geological Survey has since traced out the limits of the field, and has made considerable progress in the detailed examination of it. These seem to me to be the proper duties of that Survey, leaving the working of the coal to those more immediately interested in the success of the undertaking. And in doing this, the Survey only follow up the definite instructions they have received to confine their operations to such portions of the country as have been carefully mapped by the regular survey establishments of the country.

The coal-fields known to occur in the lower Godavery near Dumagudium, for the examination of which no funds were provided last year, have been taken in hand during the present season, and Mr. W. Blanford has proceeded there for the purpose of examining them and determining the best localities for actual borings. These are the most southerly localities in India at which coal is known to occur, and their geographical position renders them of high importance.

Among the many wild statements of the 'discovery' of coal and other minerals which constantly find their way into the columns of newspapers, and give rise to much speculation and excitement, one of the wildest seized on the public during the past year, and was urged officially on the Government of Madras. It was stated that coal, 'excellent steam coal,' 'very different from Indian coal,' &c., &c., had been found near Gooty within a very short distance of the railroad and most conveniently placed. I took no notice of the first announcement

I saw of this. But when it was circumstantially stated that not only coal, but numbers of fossils, both animals and plants, identical with those which characterized the coal-fields of Scotland and England, had been procured in the same place, these details almost made one doubt their own convictions. I should have given nothing for the stated occurrence of 'fossil ferns and beautiful specimens of coal plants,' because I had, years before, received from the same neighbourhood and sent by the same person as now announced the discovery, a large collection of what were then called 'beautiful coal plants,' but which on examination proved to be nothing but the dried and squeezed rootlets of common grasses which had inserted themselves between the cleavage planes of a true slate, and had been attached to the surfaces by a little very fine impalpable mud carried in by water. The slightest application of water washed off every trace or marking of these so-called beautiful fossils. I was therefore prepared for the assertion of 'coal plants,' but the production of a few shells said to be from rocks which had been carefully examined before, without yielding a single organism, was still to be explained. Mr. Foote was requested to visit the locality on his way to the season's work, and I purposely left him without the geological maps which had been constructed by his colleagues, desiring to leave him without a chance of having his own opinions influenced by the views of others. His results are given in a very clear and concise statement published in the first number of the 'Records,' 1871, and it will be seen that there was not to be found a single bed of rock agreeing either in colour or texture with that containing the fossils said to have been brought from that district, but which, it appears, had been previously lying unlabelled, mixed up with other fossils of all ages and localities, and picked out from this aggregate of confusion.

The coal, which certainly was, as described, 'good steam coal,' and "very different from most Indian coals," was found just in the line followed by carts which had drawn a large quantity of similar coal to a contractor's depôt not three miles off; and to test the extent of this coal, the Government were recommended to commence boring in the granite-gneiss on which these dropped fragments were found!! Anything evincing more lamentable ignorance of the very first elements of geological or mineralogical knowledge than the whole affair it would be impossible even to conceive.

This was an instance in which there could not be the slightest doubt that the gentleman who brought forward the matter did so in all sincerity of purpose and honesty of belief in its truth. But during the past year, it has been also our duty to expose a very deliberate but amusing fraud leading to the belief of the existence of coal where it might possibly have occurred, although it was highly improbable that it did, and where the sanguine anticipations of those who first made known the supposed discovery led them to picture in glowing colours future results of magnificent dimensions. These illusions led also to serious and costly practical results, which a little calmer consideration would probably have obviated.

At the commencement of the year, it was publicly stated that thick and valuable beds of coal had been unexpectedly found while boring for water within the precincts of the new Central Jail Buildings at Midnapore. This 'discovery' was widely published, and the most sanguine anticipations of results were put forward. Dr. Mouat, then Inspector General of Jails, took up the question very energetically. Such tools as could be procured here were obtained, and the borings were prosecuted with great vigour under the able charge of Major J. D. Swayne, the Executive Engineer in charge of the works of the jail. The matter did not come to the Geological Survey till some months later. In March, Dr. Stoliczka, then in temporary charge of this office during my absence, reported to the Government of Bengal that the specimens of coal which had been sent indicated a valuable fuel, but that as nothing whatever was then known of either the dip or strike or thickness of the bed, all of which were entirely concealed by a thick covering of laterite and lateritous clays, &c., no correct idea could be formed as to what quantity of coal might exist in the locality. Borings were, therefore, continued and others made. The specimens of coal sent up from time

to time were all of the same kind, and all in similar pieces. The value of this coal was tested by assay, but any opinion as to the real value of the 'discovery' was withheld until after actually visiting the place. In the middle of April I went to Midnapore, hoping to find that the boring (No. 4) then in progress would have reached the coal by the time of my arrival, and that I should be able to judge better of the nature of the bed from seeing how the fragments came up in the boring tools. I remained several days, but regret that I failed to see the coal, which was stated to have been reached some few days after my return.

However, I had the advantage of cross-questioning the man in charge of the borings, and I ascertained from him that no actual bed of coal had ever been cut, but that, as he stated, throughout a depth of nine to eleven feet, the fragments of coal had been brought up mixed with the soft slush of the red clay in which the tools were sinking. From the moment I first saw the specimens of coal said to have been brought up, I believed that they could not have been the result of the cutting of any solid bed. And it was on my stating this to the man that he at once explained the matter as I have said. His answers were clear and consistent, and the facts, if they were facts as stated, were easily reconcilable with a supposition that the tools had just struck the loose outcrop or top of a bed of coal, the detached and broken portions of which had become mixed up with the clays above. To test these statements, and to prove the continuity of the coal, if it existed, the boring rods were at once moved as far to the apparent dip of the supposed coal as the limits of the jail grounds permitted. A boring in this locality ought certainly to give, if the statements were correct, a sufficient covering of rock over the coal to preserve it from any such admixture with the clays as appeared to occur in the other borings, and would also give a satisfactory indication of the amount and direction of dip of the bed, if it proved continuous.

This boring (No. 5) was commenced, but owing to the soft nature of the clays and sands through which it passed and the want of tubing, combined with the bad boring tools at command, it was necessarily abandoned before it had reached the required depth. After a delay of nearly a couple of months tubing was procured, and another boring was put down close by. This was in September. I communicated my suspicions to Major Swayne, and asked him to take precautions to prevent the possibility of any repetition of the trick, which I suspected had been played, of putting coal down the bore holes that it might be brought up again. And this boring was carried down some 220 feet, but, as Major Swayne states, 'not a single trace of coal was found subsequently to the date on which these precautions were taken'. To satisfy himself more thoroughly, Major Swayne then very judiciously commenced a new boring close to (within a foot or two of) the first boring in which eleven feet yielding coal were stated to have been passed through. Before this was commenced, new and better tools had been procured from England, and the boring was rapidly and easily carried out.

The boring had, however, only reached about half the depth at which the coal was stated to occur, when the man in charge disappeared without leave and under very suspicious circumstances. After he had thus absconded, his house was searched under warrant from a Magistrate, and some coal was found partly in lumps and partly broken up. And on comparison of this with that said to have been brought up from the borings, they proved identical. This, however, although very strongly corroborative of the suspicions entertained, was not sufficient to establish the facts: so the boring was continued and carried right through the whole depth at which the coal was, in the first instance, stated to occur. But *not a trace of coal was found.*

These results appeared sufficient to justify stopping all further borings with a view to test the extent of the coal which was shown not to exist. One only will be continued to prove the actual thickness of the covering clays, sands, &c., in this part of the district.

Briefly then, four borings had been nearly completed before the Geological Survey had the matter brought before them, in all of which coal had been stated to occur at about the same depth from the surface. A fifth boring was necessarily abandoned from want of proper tools, and the sixth discovered the fraud. The last boring put down close by the first was simply put down as a confirmation of the results obtained from the others. And so far no evidence whatever has been obtained that coal occurs at all in this Midnapore locality.

The trick of putting coal down a bore hole so that the boring tools may again bring it up, is by no means an unknown one. It has frequently been practised in Europe, &c., and I believe this is not the first time it has been resorted to in India either. Some useful lessons may possibly be learnt from such a detection. One is the delay and doubt inevitably engendered by the use of inferior and unsuitable tools for such enquiries. Some months would have been saved had there been available proper boring tools and piping in the present case. And it was simply impracticable with the bad tools at command to keep the boring holes as clear and free as they ought to have been. It would also seem both injudicious and, therefore, costly to employ doubtful characters in matters when so much must be taken on their statements. And certainly, if men are put to such work, it would be wiser to pay them in proportion to the work they are called on to execute. The man in charge in the present case was at first a convict, and when released, he received only a wretched pittance, barely sufficient to keep him from starving and certainly not sufficient to place him above the temptation of trying to eke out his living in other ways. It is highly probable that better pay would not have kept him from attempting such frauds, but the chance of his indulging in them would unquestionably have been diminished if he had been placed above want.

But if such rogueries be sufficient to indicate the serious responsibility which attaches to those who without enquiry hurry before the public with highly coloured and exaggerated statements of such 'discoveries' and so mislead every one else, the time and money will have been well spent. If there were not a hasty and unthinking desire to gain a little fame and reward by the immediate announcement as a discovery of what was quite unproven, I have no hesitation in saying that similar tricks, even if once attempted, would certainly not be often repeated.

Major Swayne, the Executive Engineer in charge of the jail works, has throughout exhibited a very earnest and intelligent desire to test the truth of the statements made, and would certainly have proved the facts before publicly announcing them.

I refer more particularly to these considerations because as an immediate consequence of this much trumpeted discovery of coal at Midnapore came an urgent request from Madras, that a very large reward (two lakhs of rupees, £20,000, was first mentioned, afterwards reduced to one-half of a lakh,) should be offered for the discovery of a workable bed of coal south of the 17th parallel of latitude in India; the coal to be of a specified quality, and the seam of specified dimensions.

This recommendation was based distinctly and directly on the assumed fact that a bed of coal, 13 feet in thickness, had been found at Midnapore beneath a thick superficial deposit of laterite, where all the lower rocks cropping out in the neighbourhood were crystalline and much older than the coal-bearing deposits. It was urged that "the discovery of coal under such circumstances is without precedent," but that the precedent being once established other such discoveries might fairly be looked for elsewhere. And that as it was known that in the Madras Presidency vast tracts of country existed in which the geological formation of the surface agrees with the above description, no reason appeared why the discovery of coal should be a more improbable event there than at Midnapore.

It might suffice here to point out that as the coal has really not been found at Midnapore, all this reasoning, supposed to be safely based on that discovery, must fall to the ground.

But as the whole thing appeared to me to be a baseless illusion, I had to point out the reasons for this opinion. This may best be done by quoting the letter addressed to the Government of India on the matter; in this, after speaking of the terms on which it was proposed to offer such a reward for the finding of coal, and stating my belief that nothing was likely to result from such a procedure, but a useless waste of time and money, I went on to say,—"I am convinced of this not only by the general experience of the result of such offers, but even more by the grounds on which the offer is recommended. This recommendation appears to me to be based on an entire misconception of the facts regarding recent discoveries of coal, and it may, therefore, be well briefly to indicate, for the information of the Consulting Engineer for Railways in Madras, as well as others, how those facts really stand. Major S. Stewart refers to a generalized statement of mine as to the geographical limits within which the great development of coal-measures in India has been confined. That this was a very general statement he would have seen from the fact, that the coal of Assam, of Eastern Bengal, and of many other places were excluded; and so far as the argument that the productive coal-fields of India are confined to one belt across the peninsula, it was of exceedingly little importance whether the southern limits were given at the 20th degree or at the 18th degree of north latitude. In fact, if the map which accompanies the report referred to had been looked at, it would have been seen that the coal-bearing rocks were shown to extend below the 20th degree of latitude, and also that the country still further to the south was shown to be unknown geologically, regarding which, therefore, nothing was attempted to be asserted. The southern limit of the coal-bearing rocks has since then been carried further to the south than was then (1867) known, but only within the limits then indicated as unexamined."

"It is entirely correct to state that great difficulty presents itself when any attempt is made to form general conclusions regarding the mineral resources of so vast a country, But this difficulty only arises from the impracticability of actually seeing this vast area and the necessity of trusting to the information of others. There is no real difficulty in determining the facts wherever we can examine the country. Reports of mine are also quoted, stating that coal had been found in the borings in the Chanda district at places where its existence was entirely unknown or unsuspected. It was clearly not unknown or unsuspected by the Geological Surveyors, as they selected the points at which the borings were put down. But it was asserted that it could not possibly exist there by so-called practical engineers, the very class whose aid it is proposed now to invoke."

The letter goes on to argue, that because coal has been found at Midnapore under laterite, and because a considerable portion of the Madras Presidency presents a surface formation of laterite also, it cannot be seen that the discovery of coal should be a more improbable event there than at Midnapore.

"We are not in any way responsible for the statements or descriptions given in newspapers, but those quoted above certainly do not represent the facts correctly. The seam of coal (the thickness of which by the way is as yet quite unknown) does not underlie a thick superficial deposit of laterite in the ordinary or proper sense of the term. It occurs in a series of beds of sandstone, &c., of totally distinct age from the laterite, and which had been disturbed, broken up, and very largely denuded or worn away before the nearly horizontal beds of the laterite and lateritous clays were spread over them; that is, the continuity or position of one formation is not the slightest clue to the continuity or position of the other. The lower rocks also which crop up in the neighbourhood are not crystalline. The crystalline rocks show a long way to the west. But wherever there is any trace of other rocks under the laterite, those rocks are sandstones, which have become much impregnated with iron from the laterite above, and have, therefore, lost a good deal of their distinctive characters. It is

said, "so far as known, a discovery of coal under such circumstances is without precedent." But so far from this being really so, coal has not only been known, but worked for many years in the eastern end of the Ranigunj coal-field under exactly similar circumstances, the only difference being that the covering or thickness of the laterite is much less than at Midnapore. In other respects the cases are analogous."

Undoubtedly "similar discoveries may be looked for elsewhere under similar geological conditions." "But although there are in the Madras Presidency vast tracts of country in which the geological formation of the surface is laterite, there is not that I am aware of any single locality where there is the slightest reason to suppose that this laterite covers up and conceals coal-measures below. There is no place where such coal-measures appear in the adjoining country, or in any of the sections. At Midnapore there is at a limited distance to the north the extensive and rich field of Ranigunj, which is at its eastern limit all covered up with laterite. And again to the south, similar sandstones, &c., appear near Cuttack, rendering it beyond a question more probable that *if* any distinct formation did occur under the laterite and above the crystalline rocks, that formation would certainly be the coal-bearing rocks. * * But there is not as yet known a shadow of evidence that any similar conditions exist anywhere in the Madras Presidency."

PUBLICATIONS.—The "RECORDS of the Geological Survey" have regularly appeared at the fixed intervals of three months. This series has proved, as anticipated, most useful in giving early and timely notices of geological facts, which could not be given to the public for many months if it were necessary to wait for a tolerably complete report, such as could be published in the Memoirs of the Survey with maps, &c. In the four numbers for the year 1870 will be found, in addition to the annual report of the Geological Survey and of the Geological Museum, a general sketch of the geological structure of the neighbourhood of Madras; the alluvial deposits of the Irrawadi valley; geology of country around Gwalior; the Wurdha river coal-fields; the Mohpani coal-field in the Narbadda valley; geology of Mount Tilla, in the salt range, Punjab; full accounts of the copper deposits of Singbhúm; the coal near Korba, Bilaspúr, with brief notices of lead lodes at Chicholi in Raipúr; lead and copper in Manbhúm; lead ores near Sleemanabad in Jabalpur; on petroleum in Burmah, &c., and in the Punjab, &c., &c., with the customary lists of additions to our library during each quarter. The lead found in Manbhúm by Mr. Ball proved to be extraordinarily rich in silver, yielding more than 119 ounces to the ton of lead! We have had several very satisfactory testimonies to the value of this series of papers. And one of the best perhaps is the readiness with which our results are quoted in the Geological Journals of Europe, &c. The quick publication of results in this way renders it unnecessary to enter into the same detail in our annual report, for these records contain at full, or in full abstract, the descriptive reports, &c., of the officers of the survey for a large part of the year's work.

Of the larger publications, The MEMOIRS of the Geological Survey of India, we have, we regret to say, been able actually to issue only one part. Great progress has been made in the preparation of others. But it has not been possible to have the geological maps and sections prepared and ready for issue in time. A long and fully detailed report on the country lying between Madras and the Kistna river is actually printed, but cannot be issued until the map to accompany it be ready. Reports on the small coal-fields of Itkhuri (Eetcooree); of Daltongunj, or Palamaun; of Karanpúrá, south of Hazáríbágh, &c., are also ready for issue, with the exception of the maps which are to accompany them. These unavoidably take much time. They are useless unless prepared with considerable accuracy, and the colouring requires much care and special attention. This too is work which cannot be done in the ordinary way without the supervision of a geologist who understands the maps. A detailed and beautiful map of Kutch is also being printed off now. This is being printed

in colours, and will, I think, prove a very excellent and admirable record of the geological examination of the country. We are greatly indebted to Captain W. G. Murray, in charge of the Lithographic Department of the Surveyor General's Office, for the earnest and skilful attention he has given to this and other similar work, of which he has done much with his own hands, and for the friendly and zealous aid he has throughout afforded. Indeed this is only a continuation of the same earnest assistance we have invariably experienced from Colonel Thuillier and all of his valued department.

Of the PALÆONTOLOGIA INDICA, the regular issue has been punctually maintained, with only one difference. It was found by experience that the small fasciculi, which at first were issued every three months and distributed at once, were frequently lost or much injured in transmission, or were not cared for afterwards as larger books would be. And in consequence of several representations to this effect, the four fasciculi representing a twelve months' issue of these palæontological memoirs have been published as one part. The part or volume issued during 1870 contains the first portion of the bivalve mollusca of the Cretaceous rocks of Southern India (the *Pelecypoda*). These have been illustrated with the same accuracy of detail and fulness of research as were the volumes already published of the *Cephalopoda* and *Gastropoda*. And the series has elicited the very highest encomiums from the best palæontologists and geologists of Europe. Dr. Ferd. Stoliczka, Palæontologist to the Survey, has throughout maintained the same thorough and indefatigable devotion to the work he has undertaken as have hitherto distinguished his labors.

The preparation of the final geological maps to be issued on the basis of the sheets of the Atlas of India has made much progress. Two quarter sheets, including Madras Town and neighbourhood, are nearly ready (No. 78, north-east and south-east), and the copper plates of several others have been applied for, that the necessary transfers for geological purposes may be prepared.

Geological descriptions of various parts of the country have been furnished to local officers, and especially a general sketch of the Geology of Orissa to Dr. W. W. Hunter for his accounts of that province; of the Central Provinces, published in the Gazetteer of the Central Provinces; and of the Berars for the Gazetteer of those districts. Other similar sketches have been applied for, but in some cases too late to admit of their preparation in time. It ought to be borne in mind, that however brief such sketches may be, the very necessity for this condensation renders them more tedious and troublesome in preparation than a fuller report might be.

LIBRARY.—Seven hundred and thirty-seven volumes or parts of serials have been added to the Library of the Geological Survey during the twelve months under report. Of this number no less than five hundred and twenty-five have been received in exchange for the publications of the Geological Survey of India from Societies and other Institutions with which relations of exchange have been established. Of these accessions, a complete list for the three preceding months is given in each number of the Records, and to this report is added a list of all Societies or public Institutions from which, during the twelve months, donations or exchanges have been received.

We still labour under the great disadvantage of having this valuable collection of books so crowded from want of proper space for their preservation, &c., that much time is lost and great inconvenience incurred when references are necessary.

The Library of the Geological Survey has during the year been freely consulted by many besides the officers of the survey, and has proved very useful by affording access to many books not to be had elsewhere in Calcutta or in India.

MUSEUM.—The regular and systematic numbering, entering, and cataloguing of the numerous additions to our collections progresses. Always a tedious process, it is in our case rendered more than usually so by the necessity we are under, from want of space, to pack

away, after cataloguing, in boxes, a very large part of the series, and simply store them in the godowns; this difficulty which involves a very large share of additional work, whenever reference to, or comparison of, these specimens becomes necessary, will be unavoidable until the Museum obtains proper space for the exhibition of its collections and for rendering them accessible to those who desire to study them.

Mr. Tween, Curator, has been steadily progressing with the detailed examination of the coals of India in connection with the detailed experiments as to their actual 'duty', which are being carried out by Colonel H. Hyde, R. E., at the Mint Offices. When completed, it is hoped that these combined assays and actual trials will give a very much more trustworthy and accurate test of the relative values of the various coals of India, than has hitherto been obtainable. The specific gravity of each coal is carefully determined, and the general assay or composition; and then careful analysis of the ashes of the coal is made, showing the nature of their composition and the presence or absence of ingredients, which, though in small quantities, would exercise possibly a very seriously injurious effect on the results of the employment of these coals in manufactures, such as smelting of iron, &c.

METEORITES.—As stated in the Records of the Survey, 1870, pt. 4, p. 104, we have added to our large collection of Meteorites, during the past year, specimens of the fall at Hessle, near Upsala, on the 1st of January 1869; of that of Kernouve or Cleguerec, Morbihan, France, of the 23rd of May 1869; also a fine specimen of the iron of Deesa, Chili.

As customary, an index map on a small scale is appended, showing roughly the present state of the survey; as also a list of those Societies or public Institutions from which we have received publications during the twelve months in exchange for those of the Geological Survey of India.

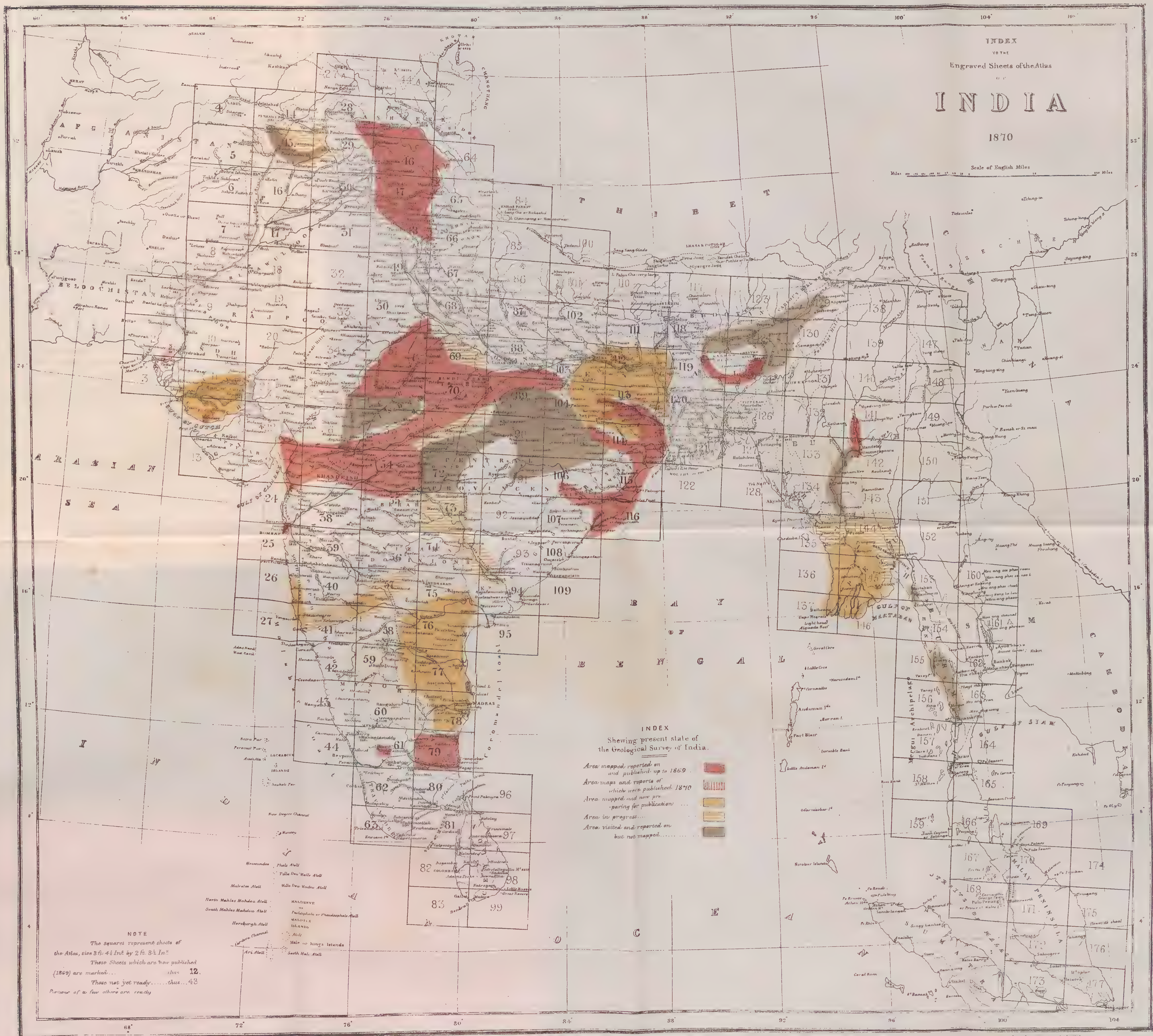
The various collections are all in as good order and safe keeping as the nature of the accommodation at our command will permit.

T. OLDHAM,
Supdt. of Geol. Survey of India, and
Director of Geol. Museum, Calcutta.

GEOLOGICAL SURVEY OFFICE,
January, 1871.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1870.

BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Royal Academy of Science.
„ Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
„ Museum of Comparative Zoölogy.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Public Library.
CAMBRIDGE U. S.—Museum of Comparative Zoölogy.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Society.
„ Royal Geological Society.
„ Royal Irish Academy.



Reduced and Photolithographed from "Hand Map of India," at the Surveyor General's Office.
Calcutta, April 1869.

EDINBURGH.—Royal Society.
,, Royal Scottish Society of Arts.
FLORENCE.—Geological Society of Italy.
GÖTTINGEN.—Königl. Gesellschaft der Wissenschaften.
LAUSANNE.—Société Vaudoise des Sciences Naturelles.
LONDON.—Royal Institution of Great Britain.
,, Royal Geographical Society.
,, Royal Society.
,, Royal Asiatic Society of Great Britain and Ireland.
,, Geological Society.
,, Geological Survey of Great Britain and Ireland.
,, Society of Arts.
MOSCOW.—Société Impériale de Naturalistes.
MÜNICH.—The Academy.
NEUCHATEL.—Society of Natural Science.
NEW YORK.—Museum of Natural History.
NORWAY.—Royal University of Christiania.
PALERMO —Consiglio di Perfezionamento di Palermo.
PARIS.—Comm. des Annales des Mines.
,, Société Géologique de France.
PHILADELPHIA.—American Philosophical Society.
,, Franklin Institute.
,, Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Essex Institute.
,, Peabody Academy of Science.
STOCKHOLM.—Royal Academy of Science.
,, Bureau de la Rech. Geol. d. l. Suede.
ST. PETERSBURG.—Acad. Imp. des Sciences de St. Petersbourg.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Sciences.
,, Academy of Turin.
VICTORIA.—Govt. Geological Survey of Victoria, Department of Mines.
VIENNA.—Kais. Akad. der Wissenschaften.
,, K. K. Geologische Reichs-Anstalt.
WASHINGTON.—Smithsonian Institute.
,, National Academy of Sciences.
ZÜRICH.—The Society.

Governments of India, Madras, Bombay, Bengal, N. W. Provinces, Punjab; Chief Commissioners of Oude, Central Provinces, and British Burmah; Surveyor General of India, &c., &c.

RESULTS OF AN ENQUIRY INTO AN ALLEGED DISCOVERY OF COAL NEAR GOOTY, AND OF INDICATIONS OF COAL IN CUDDAPAH DISTRICT, *by* R. BRUCE FOOTE, F. G. S., GEOLOGICAL SURVEY OF INDIA.

Dr. Hunter in his letter to the Madras Government which I perused by desire of the Hon'ble R. S. Ellis, C. B., the Chief Secretary, stated that he was led to examine a certain piece of ground lying west of the Adoni road, and about five miles from Gooty, by hearing from a Sergeant Fenner, stationed at that place, that he had picked up fragments of coal at the above spot.

Dr. Hunter himself picked up one or two more fragments of coal, lying loose on the surface, at the same place, and from this inferred the existence of coal below the surface, and recommended that a further search should be carried out by means of 'borings.'

In order that no possible mistake should arise in identifying the spot in question, I requested Sergeant Fenner to become my guide to it, and accordingly visited it under his guidance.

The place I was taken to proved to be situate among the metamorphic rocks, which, at that spot, consist of an extremely hard, massive and highly crystalline variety of granite-gneiss, forming a low rocky hill west of Yerragoody tank. This granite-gneiss, which weathers into great tors and rounded lumps, is of a pale, pinkish or greyish white color (when freshly broken) speckled with small crystals of black mica in considerable numbers. Both here and throughout the neighbourhood it is traversed by trap-dykes (generally of green stone) and small quartz veins.

It was very evident therefore the coal fragments collected here could not have been derived from the underlying rock, but must have come from elsewhere, but no younger rocks out of which they might have been washed, or weathered, occur anywhere in the immediate vicinity. The nearest place at which younger rocks occur is fully eight miles to the eastward where beds of quartzite and limestone appear; these belong to the Cuddapah (Kadapáh) series which is nowhere known to contain coal or any carbonaceous mineral. That the fragments of coal found by Dr. Hunter and Sergeant Fenner could not have been washed there out of the Cuddapah rocks is quite clear, as no drift of any kind occurs at the level where the fragments in question were found, which cannot be less than from 30 to 50 feet above the nearest valley, that of the little stream which fills the Yerragoody tank. Furthermore the fragments of coal in question are perfectly angular, with an unweathered surface, never having been rolled by water.

No fragments of coal remained at the time of my visit to the Yerragoody hill.

Sergeant Fenner pointed out as "most favorable indications of coal" according to Dr. Hunter, what proved to be the rather decomposed surface of a small trap-dyke exposed in a ballast pit close to the road. A hummocky intrusion of coarse dioritic trap was, on the same authority, given as "iron ore."

In conclusion, I have no hesitation in believing that the fragments of coal found by Dr. Hunter and Sergeant Fenner had been brought to the spot where found by some human agency.

They were either brought from a coal depôt belonging to Mr. E. W. Barnett, C. E., the Railway Contractor, the remains of which may still be seen at the spot where the Gooty-Adoni road crosses the railway, a distance of only three miles from the Yerragoody hill, or else they may have been dropped from the carts in which Mr. Barnett carted a quantity of coal up to Adoni, previous to the time of Dr. Hunter's visit.

In the latter case the carts would have to pass within a few yards of Dr. Hunter's supposed coal-field.

Among the remains of Mr. Barnett's coal depôt at the crossing over the line, to which my attention was directed by Mr. Barefoot, the very obliging Locomotive Foreman at Gooty Station, I picked up various pieces of slaty north-of-England coal identical in appearance with the specimens from Yerragoody hill, which Dr. Hunter exhibited to His Excellency Lord Napier and the members of Council on the occasion on which I was desired to attend.

2.—*Indications of Coal near Cuddapah.*

Dr. Hunter's informant as to the existence of good indications of coal near Cuddapah was, I believe, a Mr. Adams, a *soi-disant* 'experienced coal miner from Chanda.'

The spot indicated as showing such promising indications of coal lies about five miles north-north-west from Cuddapah where the limestones (here belonging to the Kurnool (Karnúl) series) have been largely quarried in deep pits, a little to the east of the village of Chinna Mazapully. These pits at the time of my visit were quite full of water, but the waste heaps, which I went over carefully, showed not the faintest indication of coal or coal shale.

In addition to the negative evidence afforded by the waste heaps, I ascertained from Mr. Higginson, the Irrigation Company's Engineer at Cuddapah, who has worked the self-same quarries largely, and for weeks together been in the habit of constantly visiting them, that he has never seen the smallest trace of carbonaceous matter in any part of the rocks there exposed.

As Mr. Higginson is not only an experienced Civil Engineer, but also a careful and thoughtful observer of facts, his evidence may be very safely accepted as conclusive of the non-existence of coal or coaly matter at this place.

Dr. Hunter did not, I believe, visit this place personally, but merely brought Mr. Adams' supposed discovery to the notice of the Madras Government.

3.—*Fossil shells and petroleum near Ryalcheroo.*

In his letter to the Madras Government above referred to, Dr. Hunter further stated that he believed coal occurred in the rocks lying between Ryalcheroo (in Bellary District, fifteen miles south-east of Gooty) and Cuddapah, and advanced three reasons especially for such belief; firstly, the presence of fossil shells '*Terebratulæ*' in the limestone near Ryalcheroo; secondly, the presence of petroleum in limestones at Khona Oopalapad, six miles north-east of Ryalcherroo; and thirdly, the black color of some of the limestones occurring between Tadputri (Taudapurtee) and Cuddapah!

Dr. Hunter produced before the Council two fossil shells (*Terebratulæ* of a species somewhat resembling *T. hastata*) which he stated came from Ryalcheroo, where they had been found some years ago by Major Bissett (since deceased, I believe), and added that the late Mr. Robert Cole, Inspector General of the Indian Medical Department, Madras, had also collected similar fossils at the same place.

As Dr. Hunter could give me no information as to the exact locality near Ryalcheroo whence the fossils came, and I had not the maps of that neighbourhood, prepared by my colleagues, a great deal more time was required to investigate this point than would have been otherwise necessary.

I examined a very large number of beds of limestone with intercalated slates, shales, quartzites, &c., &c., without finding the slightest trace of any organic form, some very doubtful worm-tracks excepted.

None of the limestones agree in color or texture with that which yielded Dr. Hunter's specimens, and I cannot help having the strongest doubts as to the correctness of Dr. Hunter's statement that the *Terebratulæ* in question came from Ryalcheroo, or any other place in that neighbourhood, as the statement in question rests only on the authority of his memory, which in this instance has, I firmly believe, played him false.

When Dr. Hunter showed me those *Terebratulæ* some days before the meeting of the Council, they were *unlabelled* in a drawer containing many other fossils from Europe, equally unlabelled, and mixed up together regardless of geological age, or natural orders. Whatever Major Bissett's specimens may have been, I cannot but think that, from trusting too much to his memory, and from keeping his collections in a state of utter disorder, Dr. Hunter has made a mistake, and unintentionally taken some European specimens for Major Bissett's.

The presence of petroleum in the limestones at Khona Oopalapad might offer some little support to Dr. Hunter's expectations of finding coal in the Cuddapah rock series, if proved, but unfortunately no petroleum can be found there.

The only substance which, following his directions, could be found at Khona Oopalapad, either by Mr. Kelsall, the Acting Sub-Collector of Bellary, or by myself, was a dark brown, glistening, fœtid substance which has dribbled out of numerous small caves in the face of the cliff overhanging the Khona Ramaswamy Pagoda.

This substance, though somewhat resembling petroleum in color, differs very markedly by refusing to burn. Before the blow pipe it volatilized without any appearance of flame.

The small caves out of which this brown substance dribbles are tenanted by numerous bats and blue pigeons whose excrementa are, by percolation of water in wet weather, converted into a species of guano retaining a very unpleasant bat-like odour.

The limestone cliffs in which this 'bat-guano' occurs do not belong to the Cuddapah rock series, but are formed of a recent travertin deposited on the scarp of those older rocks by streams flowing from a more elevated plateau of limestone (of the Kurnool (Karnúl) series), which lies unconformably on them.

The small caves are mostly spaces left between numerous large stalactites in the travertin, others are of artificial origin. The travertin is still being formed, but probably in far less quantity than in former periods when the country was less arid. Numerous organisms, such as land-shells, and leaves of trees of living species, have been encrusted by the travertin, and their impressions are beautifully clear.

The 'bat-guano,' I find, had been pronounced by my colleagues, the late C. Æ. Oldham and W. King, Junr., not to be petroleum. I was not aware of this till after my visit to Khona Oopalapad.

In reply to a letter in which I drew his attention to the fact that the supposed petroleum refused to burn, Dr. Hunter informs me that the specimen he received from Mr. Smart, late Chief Engineer of the Madras Railway, burnt with a strong flame, dropping and giving off much gas, but he does not know exactly from where Mr. Smart got it. I intend writing to Mr. Smart on this subject as soon as I can ascertain his present address.

It thus appears that none of Dr. Hunter's statements have been substantiated, while the most important have proved to be entirely without foundation. These statements were no doubt made by Dr. Hunter in a sincere belief in the correctness of his deductions, but the latter, unfortunately, were based on a series of hasty, crude, and in some cases utterly incorrect, observations evidencing such a want of practical knowledge of geology and several other sciences that in future his 'geological discoveries' should be received with extreme caution.

Mineralogical Statistics of Kumaon Division, collected under instructions from the Commissioner, Colonel H. Ramsay, c. b., by A. W. Lawder, Civil Divisional Engineer.

While submitting these mineralogical returns for the past year (1869-70), I would call attention to the statement commencing my last year's report, and to the remarks now made by Captain Garstin. While every care has been taken to check as far as possible the correctness of the details, still too much reliance cannot be placed upon them. It is not the special duty of any native officials in the several parts of the districts to collect the information required, and those from whom it is asked not understanding the object for which it is sought, or seeing any direct advantage to be derived therefrom, are liable not to be overcareful in making their calculations; and it should therefore be remembered that the figures entered are merely approximations and not actuals. Specimens from most of the mines mentioned in the returns having been received by me, I have endeavoured to give a description of their character and species, so far as I can determine them by the ordinary rough tests.

DETAIL OF LOCALITIES.

Kumaon District.

Iron.—*Agar Puttí—Lúsgani mine.*—The specimens are rich in metal, of a laminated structure, black colour, are slightly micaceous, and influence the magnetic needle. They may possibly contain Manganese.

Agar Puttí—Nutthúa Khan mine.—A micaceous ore rich in metal, laminated, affects the needle slightly.

Agar Puttí—Sutbúnga mine.—A rich hæmatite, influences the needle.

Agar Puttí—Gulla mine.—Ore similar to that of the Nutthúa Khan mine.

Lukhunpúr Puttí—Munia mine.—The ore is seemingly an earthy red hæmatite, minute particles of yellow metal appear here and there, of which I have no means of testing the nature.

Darún Puttí—Diguria mine.—This specimen is also an earthy red hæmatite.

Rungourh Puttí—Diguria mine.—Ore possibly a clay ironstone. In parts affected by acid similarly to spathic iron.

Rungourh Puttí—Julal mine.—This resembles micaceous iron schist.

Kharai Puttí—Lobe mine.—This ore is apparently a brown hæmatite.

Mulla Kutyoor Puttí—Lugthan mine.—Similar to the last named specimen.

Burâon Puttí (Gangúlí).—A black micaceous ore apparently rich; laminated, and influences the magnetic needle.

Copper.—*Bâel Puttí* (Gangúlí)—*Bujúl mine.*—This ore is a copper pyrites. The matrix is composed of steatite and felspar.

Bâel Puttí—Rethayat mine.—Specimen similar to the last mentioned.

Gungúlí Puttí—Tamba Khan.—This ore is pyrites, and is apparently rich in metal, talcose rocks form the gangue.

Athagâon Puttí (Gangúlí)—*Fudialí mine.*—Specimens from this mine do not seem very rich in copper. In a matrix of talcose schist pyrites is disseminated in small particles.

GURHWAL DISTRICT.

IRON.—*Pykunda Puttí.*—These specimens exhibit granular iron pyrites imbedded in veins of quartz which occur in a dark greyish talcose schist. They are apparently not very rich in ore.

Sílí Chandpúr Puttí—Rajbúnga mine.—This is a hæmatite, rich in quality. It is slightly attracted by the magnet.

Sílí Chandpúr Puttí—Khúsh mine.—This is evidently a micaceous ore, scaling off easily, minute crystals, resembling garnets, can be observed on the sides of the specimens. The adjacent beds seem to be chlorite schist. The ore affects the needle.

Putti Bichla Nagpúr—Búkhunda mine.—Specimens from these mines are also of a micaceous nature, and seem to contain in parts, minute crystals of quartz, pyrites, &c., otherwise it much resembles graphite, and leaves minute particles upon the fingers when touched. It does not influence the compass needle.

Puttí Bichla Nagpúr—Jakhtolí mine.—This ore is probably a clay ironstone. It is of a light coffee colour, and of little specific gravity.

Puttí Bichla Nagpúr—Gílet mine.—This ore is similar to that of the Bukhunda mine.

Puttí Mulla Dussolí—Mok mine.—The specimens appear to be magnetic iron ore rich in mineral; colour black, structure crystalline, and laminated. It possesses highly magnetic properties.

Puttí Mulla Dussolí—Churbung mine.—This corresponds to that of the Mok mine, one fragment is a natural loadstone and exhibits its polarity in the direction of the planes of lamination. (?) It seems very rich in iron.

Puttí Buchursyun—Dúgura mine.—It is difficult to define of what nature these specimens may be: possibly an earthy hydrated oxide of iron. Its colour varies from yellowish-brown to dusky black, streak the same. It is of little specific gravity, the clay seemingly predominating.

Puttí Idyakote—Pípulí mine.—Probably a hydrous form of sesquioxide of iron, clay largely predominates.

Puttí Idyakote—Danda Tolí mine.—The ore from this mine seems an argillaceous variety of brown hæmatite.

Puttí Painú—Chulya mine.—Very similar to the last mentioned.

A specimen of iron ore brought from the neighbourhood of Milum, called by the natives of Mulla Johar '*Buldúnga*', seems a crystalline variety of red hæmatite. It is used there for a red dye, the colour being extracted by rubbing the stone on a hard surface while wet.

SULPHUR.—This occurs frequently in the clay shale, and argillaceous rocks in the lower ranges. A stream running down beside the suspension bridge at Katgodam contains it in solution. A stream near Nurgolí village (new Thul Road) Puttí Athagaon is strongly impregnated with sulphur, and deposits it freely upon twigs, leaves, &c.

SALAJIT.—With reference to my remarks upon this substance in my last report, and a note by Dr. Oldham thereon, I would mention that I was led to form my opinion from a substance called Salajit and sold as such, which was brought to me from Gurhwal as the

pure mineral. I have since forwarded some of this to Mr. Tween, who has been kind enough to analyse it. Here is what he says :—

"It contains nothing but a very sandy clay, mixed with some strong bituminous matter. It burns vigorously for a short time like a coal, but soon ceases, and leaves without diminishing in bulk, nothing but the clay behind;" thus I was not much in error in naming it as bitumen.

On further enquiry, however, I find that this is *not* the pure mineral, it may contain a small amount of it, but is otherwise largely adulterated. I have not as yet been able to visit the place from whence salajit is collected, but from intelligence obtained from several *Hakims*, I am led to believe that the pure mineral here known as salajit is in all probability similar to that of Nepal, which Dr. Oldham states is a native sulphate of alumina.

Salajit is used as a medicine. It is said to be a specific in colds or influenza; to ease pains in the heart and lungs; in rheumatism, taken internally and externally; it is given with nitre in affections of the kidneys; to cure Impotency, and is used as a Tonic; and also as a lotion to wounds, &c.; it is valued at 4 annas to Re. 1 per tola, according to quality.

Sulphate of alumina is also to be found on some of the aluminous shales in the lower ranges in Kumaon. It can be seen on the road between Nainí Tal and Khyrna, near Jak village. The shale contains minute particles of pyrites disseminated throughout its mass which decomposing promotes the formation of alum. The infiltration of water causes lixiviation, and the alum is left as an encrustation on the outside of the rock.

TALC.—A kind of dark-coloured Talc called *Jalposhe* seems also to be used as a medicine, either alone, or combined with other substances after it has been very finely pulverized. It is said to have cooling and tonic properties, is given in fevers, and in expectoration of blood from the lungs. These properties possibly arise from the amount of magnesia and iron it may contain.

SLATES.—Two specimens (in addition to those mentioned before) of clay slate have come under observation this year, one from Dhāree village, Puttí Baêl, (Gangúlí,) and the other from Bora Rao Puttí. They are apparently much inferior to the Chitélí slate in every respect.

IMPORTS AND EXPORTS.

From the annexed tables prepared from information obtained from the respective Tehsils and Thannas, and from the statement from Gurhwal, the amount of borax altogether imported through the ghats of Darma, Milum, and Nití, including some from the Byanse and Choudans ghats, was maunds 31,473, or much less than shown in last year's returns. The amount entered in the return from Chumphawut is taken by me as a portion of the amount entered in the Petwa return, as it passes through Chumphawut *en route* for Burmdeo and Píleebheet. A large quantity of borax direct from Choudans, Byanse and Darma finds its way into Nipal. The Tibetan authorities exact a tax in kind upon the export of borax to British territory of one load of grain for every ten loads of borax. It is carried by goats and sheep in a sort of pack with a pair of pockets slung over the back, one on each side. The pockets are covered with leather to keep out wet and damp when piled on the ground. This pack is girthed underneath the body, a band round the chest and another under the animal's tail render it perfectly safe. Each goat is supposed to be able to carry eight seers (or 16 lbs), and the pockets are made sufficiently capacious to hold that weight of grain.*

* It is marvellous to observe the business-like way in which these little beasts of burden carry their loads! Coming upon them on the very narrowest, steepest and slippiest ascent on the brink of a precipice they seem intent only upon pursuing their way, not turning aside for any one or anything, their obstinacy often causing the traveller uneasiness and teaching him patience. And not the less curious is it to observe flocks of them numbering many hundred each meeting, each going the contrary way, and yet none make a mistake, but persist in following their own leader and patiently overcome all obstacles to their doing so.—A. W. L.

The salt returns show a greater total amount than those of last year and would seem to be—

		Mds.
Salt imported *viâ* the Johar (Milum) Pass in 1869-70 about ...	... ...	3,000
" " Nití and Mana Passes in 1869-70 about	...	3,521
" " Darma and Byanse Passes in 1869-70 about	...	4,000
Total	...	10,521

It is sold at Bagesur at about Rs. 5 per maund, and by Almorah bunyas at Rs. 7 per maund. The Bhotias generally barter all their salt for grain.

Salt is also imported from the Punjab and Sambhur Lakes. Lahorí (Punjab) salt is generally most esteemed, and is considerably whiter than the other two. It averages from 2 to 3½ seers per rupee in the Almorah bazaar, whereas the Bhotia and Sambhur salts (of similar value) sell at from 4 to 6 seers per rupee, the fluctuations depending upon the amount available. The total amount of Indian salt imported appears from the accompanying statements to have been about 21,000 maunds, but this is probably below the mark, as no mention of it is made in the Gurhwal returns.

GOLD.—The amount of gold brought from Tibet and disposed of at Bagesur during the year appears to have been about Rs. 10,000 worth. It averaged Rs. 14 per tolah. It is collected in grains and dust from many of the Tibetan rivers, the authorities taking a percentage upon the amount realized.

SILVER.—Silver was brought down to these provinces from Tibet in former times. It was imported into that country from those surrounding it (probably China), and does not seem to be found in Tibet itself in any quantity. It was sent into Tibet in a crude state in lumps called *Doja* or *Thukka* of a general value of Rupees 165 each. Importations from that source have, I believe, ceased for some time, owing possibly to the great and growing influx of silver in the shape of rupees from British territory. Formerly all borax, salt, &c., was bartered for grain, cloth, &c., but now while a large amount is still disposed of in that way (probably to procure actual necessaries), still, whether it proceed from the increase of trade, and the portability of coin for hoarding purposes, or from the existence of a greater demand for silver in Tibet, by far the largest amount of borax is disposed of here for British money. And I may mention that the Bhotias state that our coin is largely current in Gurtok and the other large towns, and is preferred by the inhabitants there to the coinage of other countries. They ask for the Cheharádár Rupayá or face-printed money.

The Bhotia traders are only allowed to go as far north as Gurtok and Durchín. Further progress is impeded by the Tibetan authorities.

COPPER.—A large quantity of copper seems to be imported from the plains.

IRON.—The import returns seem to be 2,000 maunds from, against 155 maunds exported to, the plains.

LIME.—The returns show 1,00,000 maunds of lime sent to the plains from Ramnugger and Chorgullia only.

I forward herewith a return sent to me from Gurhwal by Captain Garstin together with some remarks by him thereon.

24th August 1870. A. W. LAWDER.

IMPORTS. *Chumphawut and Burmdeo.*

NAME OF MINERAL.	Number of Maunds.	From whence.	Value at Chumphawut.	Ultimate destination.	Value there.	REMARKS.
			Rs.			
Brass	...	The Plains ...	1,000	The Hills.		
Kansa (alloy of copper and zinc.)	...	Ditto ...	400	Ditto.		
Borax	9,000	Tibet ...	80,000	Pileebheet ...	1,25,000	
Coarse Salt (common)* ...	...	The Plains ...	10,000	The Hills ...	...	* Villagers purchase at Burmdeo and take to their houses in the Hills.
Ditto (common)† ...	4,000	Tibet ...	20,000	Petora, Chumphawut, and Burmdeo.	...	† Consumed in the Hills.
Salajít	...	Khurkdes and Nepal	10	The Plains.		

Petoragurh.

NAME OF MINERAL.	Number of Maunds.	From whence.	Value at Petora.	Ultimate destination.	REMARKS.
			Rs.		
Brass	...	The Plains ..	8,000	The Hills ...	Sold at the New Thul Fair.
Salt	4,000	Tibet ...	20,000	The Hills.	
Borax	16,000	Do. ...	1,60,000	Burmdeo and Pileebheet.	
Salajít	...	District ...	15	District.	

Ramnagar.

NAME OF MINERAL.	Number of Maunds.	From whence imported.	Value at Ramnagar.	Ultimate destination.	REMARKS.
Iron	55	The Hills ...	Rs. 10 per md.	Sold at Ramnuggur.	
Ditto	1,000	„ Plains ..	„ 8 „	Ditto.	
Copper	5	„ Hills ...	„ 70 „	The Hills.	
Ditto	300	„ Plains ...	„ 70 „	Ditto.	
Lead	10	Do. ...	„ 12 „	Ditto.	
Gold	...	Do. ...	„ 1,000	Ditto.	
Ditto Mohurs ...	...	Do. ...	„ 10,000	Ditto.	
Borax*	15,000	Tibet ...	......	The Plains.	* Sold at Bagesur for Rs. 11 per maund, and at Ramnagar, when cleaned, at Rs. 22 to 24 per maund.
Salt (common) ...	15,000	„ Plains ...	„ 67,500	„ Hills.	
Salajít	2	„ Hills ...	Re. 1 per tola.	1 seer sold at Ramnagar, remainder to the Plains	
Lime (Stone and Tufa) ...	90,000	Do. ...	Rs. 18 per 100 maunds.	The Plains.	

Huldwaní.

NAME OF MINERAL.	Number of Maunds.	From whence imported.	Value at Huldwaní.	Ultimate destination.	REMARKS.
			Rs.		
Iron	100	The Hills ...	1,000	Sold at Huldwani.	
Ditto	1,250	The Plains ...	10,000	The Hills.	
Copper	...	Ditto ...	2,000	Ditto	
Lead	...	Ditto ...	500	Ditto	
Gold	...	Ditto ...	10,000	Ditto	In gold mohurs.
Sulphur	...	Ditto ...	50	Ditto	
Borax	7	Tibet ...	98	The Plains.	
Salt	...	The Plains ...	20,000	„ Hills.	
Salajít	...	„ Hills ...	25	„ Plains.	
Lime	...	Chorgullia, Bhabur.	10,000	Ditto ...	Sold at the foot of the Hills at Rs. 18 per 100 maunds.

Return of amount and value of all kinds of mineral produce brought

Name of Putti.	Name of Mine.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after smelting ore.
					Maunds.	Maunds.	Maunds.
Kutowlee	Siyalbarree	Iron ...	By digging rock ...	700	3	55	8
Ramgurh	Dusoula	„ ...	„ ...	4,300	160	500	200
„	Buna	„ ...	„ ...	2,000	90	200	65
„	Palee, &c.	„ ...	„ ...	2,200	120	150	72
Agar	Putbara	„ ...	„ ...	4,100	144	225	150
„	Mujera	„ ...	„ ...	4,300	112	330	130
„	Losgyanee	„ ...	„ ...	4,000	130	450	220
„	Nuthúakhan	„ ...	„ ...	4,300	135	525	235
„	Gulla	„ ...	„ ..	200	20	24	5
„	Súnkea	„ ..	„ ...	120	19	40	10
„	Chowkhoota	„ ...	„ ...	124	40	39	18
Lukhunpore ...	Munia	„ ..	„ ...	600	220	60	31
„	Chanee	„ ...	„ ...	500	32	18	12
„	Beena	„ ...	„ ...	300	16	22	12
„	Kanchoola	„ ...	„ ...	300	15	17	4
Darún	Ludholee	„ ...	„ ...	660	60	150	130
„	Madum	„ ...	„ ...	700	70	144	120
„	Ghoorkúnda	„ ...	„ ...	900	75	130	125
„	Mutkadria	„ ...	„ ...	750	52	126	132
Rungourh	Buna	„ ...	„ ...	5,000	300	800	400
„	Ookhulgara	„ ...	„ ...	6,000	230	600	300
„	Jirtolee	„ ...	„ ...	250	30	125	134
Gewarh	Khetsaree	„ ...	„ ...	9,000	80	600	300
„	Godee, Sirolee, &c. ...	„ ...	„ ...	8,300	65	700	250
Mulla Kutyoor ...	Lugthán	„ ...	„ ..	400	25	40	4
Tulla Johar ...	Mulla Mainskote ..	„ ...	„ ...	450	25	33	7
Kharaí	Lob	„ ...	„ ...	525	35	35	4
„	Goul	Copper	Deep shaft ...	4,000	1	13	9
Buraôn	Rai	„ ...	„	3,700	3	14	2
„	Belarh	„ ...	„	2,550	2	3	1
„	Lettee	„ ...	„	550	2	2	2
Tullee Row ...	Naee, Boree, &c.... .	Iron ...	By digging rock ...	1,000	2	14	7
Seera	Agar	Copper	Deep shaft ...	100	......	15	15

KUMAON;
CIVIL DIVNL. ENGR.'S OFFICE,
The 25th August 1870.

to market or raised for private use in Zillah Kumaon for the year 1869.

Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of lead.	Mines of slates.	Mines of lime.	Remarks.
Maunds.					
10	Salt, borax, gold, imported from Bhoot, north of Kumaon; copper, brass, lead, zinc and iron chiefly imported from the plains.	There is one mine of lead in Putti Kharai which is lying unworked.	There are many mines of slates in the District.	Limestone is plentifully found close by in almost every part of the District, except in the neighbourhood of Almorah and within a radius of about 15 miles therefrom.	Partly sold in the neighbourhood and partly sent to Almorah, Huldwani and Nynee Tal.
200					Ditto ditto.
75					Ditto ditto.
82					Ditto ditto.
125					Ditto ditto.
225					Ditto Ramnagar and to ditto.
192					Ditto
244					Ditto Huldwani ditto ditto.
7					Ditto ditto
12					Ditto ditto
16					Ditto ditto
12					Ditto Thul, Ramesur, Bagesur and Almorah.
12					Ditto ditto ditto.
7					Ditto ditto ditto.
3					Ditto ditto ditto.
70					Ditto ditto ditto.
60					Ditto ditto ditto.
50					Ditto ditto ditto.
48					Ditto ditto ditto.
400					Ditto ditto ditto.
300					Ditto ditto ditto.
125					Ditto ditto ditto.
300					Ditto Gurhwal.
400					Ditto ditto.
8					Ditto Bagesur.
12					Ditto ditto.
3					Ditto ditto and Almorah.
10					Ditto ditto ditto.
4					Ditto ditto and Thul.
4					Ditto ditto ditto.
3					Ditto ditto ditto.
7					Ditto Burmdeo.
......					Ditto Thul.

A. W. LAWDER,
Civil Divisional Engineer, Kumaon.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah Gurhwal for the year 1869.

Name of Putti.	Name of Mine.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after smelting ore.	Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of sulphur.	Mines of slates.	Amount of Bhotia salt imported.	Amount of borax imported.	Amount of gunda-biroja exported.	Remarks.
					Mds.		Mds.	Mds.							
Dhunpoor	Dhunpoor	Copper	Deep shaft ...	1,201	16	...	10	...	Unknown.	There are two mines of sulphur in Mulla Nagpoor and one in Mulla Dusolee which are all lying unworked.	There are many mines of slates in Puttees Goojroo, Chundkot, Gugwarsyoon, Khatsyoon, Iriakote, Dewulgurh, Bijlot, Khatlee, Choprakot and Lohba.	3,521 Maunds.*	473 Maunds.†	1,977 Maunds.‡	* Salt is brought from Tibet; its original cost is about 16 seers per rupee, but when sold in this District it averages about 8 seers, and Bunnyas sell at 5¼ seers this year. † Borax is also purchased in Tibet. This year it has realized Rs. 22 per maund. ‡ The export of gunda-biroja has been stopped, owing to the destruction caused to the Cheer forests by extracting it. It used to sell at about 5 seers per rupee.
Ditto . ..	Fachoda	Lead...	Ditto ...	100	1	...	1	...							
Mulla Nagpoor	Hat Jaisal	Iron ..	Ditto ...	750	10	...	4	...							
Bichla Nagpoor ...	Agur Jakhtolee ..	Do. ...	Ditto ...	720	20	...	14	...							
Ditto ...	Goolet	Do. ...	Ditto ...	720	15	...	15	...							
Ditto ...	Bhookunda ...	Do. ...	Ditto ...	360	14	...	8	...							
Boongee	Buwanee Mudaoo Charn	Do. ...	By digging earth	100	7	...	4	...							
Lohba	Simulkhet	Do. ...	Deep shaft ...	700	50	...	50	30							
Mulla Dusolee ...	Churbung	Do. ...	By digging earth	100	25	...	50	...							
Nundak	Mokh	Do. ...	Ditto ditto ...	300	50	...	50	...							
Painoo	Chulya	Do. ...	Collected from different parts.	280	50	...	12	...							
Iriakote	Dandatolee... ...	Do ...	Ditto ..	120	32	...	8	...							
Ditto	Pipulee	Do. ..	Ditto ...	60	6	...	3	...							
Seelee Chandpore ...	Rajboonga	Do. ...	Deep shaft ..	300	60	...	35	...							
Kurakote	Koos	Do. ..	Ditto ...	200	60	...	20	...							
Buchunsyoon ...	Doongra	Do. ...	Ditto ...	960	100	...	90	90							

GURHWAL;
SENIOR ASSTT. COMMR.'S OFFICE, PAORI,
The 18th July 1870.

C. J. GARSTIN,
Offg. Sr. Asstt. Commr.

Captain Garstin, in forwarding the Gurhwal returns, says (18th July, 1870) :—

I have the honor to forward the annual statement regarding produce of mines, &c., in Gurhwal.

2. There is a considerable difference between the figures now shewn and those of last year. This will be the case for some years to come, till the Putwarees, who have to compile the returns, and the miners who give the information, understand better what is required. At present the latter suspect that there is some ulterior reason for the information being called for, and are therefore chary of giving it.

3. It is quite impossible to find out to what parts of the country the metals extracted are sent, or in what quantities, as they are not sold at fairs, in this district: indeed there are no large fairs, where sales take place usually. Those wishing to purchase go themselves to the miners and do so, and unless some person to register sales were appointed for each mine, it is quite out of the question to attempt any compilation of this kind of information.

4. Iron usually sells at 3 seers per Rupee, but if made up into vessels its price is $2\frac{1}{2}$ seers. Copper sells at Re. 1-8, or Rs. 2 per seer, if made into vessels.

5. As regards the statistics of salt, borax, and gunda-biroja since asked for by you, the return shews pretty nearly the quantities imported and sold and the prices prevailing. The latter article used to be exported in considerable quantities, but owing to the destruction caused to the Cheer forests in extracting it, this traffic has been put a stop to.

6. In conclusion, I would add that for the reasons given in my 2nd paragraph, too much reliance must not be placed on these statistics, all they are worth is to show approximately the quantities of metal, &c., produced.

7. This return would have been sent in before, but further information was lately called for, which had to be collected, and hence the delay.

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RECORDS
OF THE
GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1871. [May.

The Axial group in Western Prome, British Burmah, by W. Theobald, Esq., Geological Survey of India.

When examining the southern portion of the Arakan range, I applied the term 'axials' to a group of rocks which seemed everywhere to comprise the central region or axis of the range, but the relations of which to the newer or nummulitic group were not there very clearly displayed, partly from the nature of the ground and partly from the character of the beds which, though of great thickness, were very deficient in any salient points for arrangement and sub-division. In Western Prome, however, there is a great improvement in these respects, and the axial group is so well displayed that we obtain, not only a good insight into its relation with the newer group which adjoins it, but, from a few good sections, a tolerable conception of its own principal stratigraphical sub-divisions. The best and most illustrative sections are met with near the frontier, particularly in the Hlowa stream, where an enormous thickness of beds dips with much regularity and at a high angle, the section comprehending beds of both the axial and nummulitic groups.

As we go south the breadth of country covered by this group increases materially, and with this increase in breadth, there is a proportionate change in the arrangement of the beds, the high steady dip observable to the north there becoming replaced by a variable, and often extremely low, one.

At the frontier, these beds are 13 miles in breadth measured from the crest of the range at right angles to its general strike, which breadth is diminished to 7 miles at Shuedoung, a remarkable hill thirteen and a half miles south-west by south from Mendoon. From this point the 'axials' gradually expand till they attain their greatest breadth of twenty miles at Thabie Sukan, a halting place on the Arakan road.* The relations of the axial and nummulitic groups are nowhere better seen than along the frontier, proceeding west from the village of Sangyi. The road from Sangyi to Yebile (Yua-ba-lay in map) lies over an undulating and in part hilly country of the ordinary character seen within the outer ranges of hills composed of nummulitic strata. The forest is moderately thick and the low vallies rather well supplied with water, (considering that the previous rainy season had been very scanty, and most of the streams were unusually low in consequence). From many points along this line of road, the bolder character and denser forest of the main Arakan range formed a prominent and

* It would seem to have been no fortuitous circumstance that dictated the adoption by the Burmese of the line along which the Padoung and Tonghoop road (Arakan road) now runs, and which is the line along which the Burmese formerly transported, at great cost and toil, a colossal image of brass of Gaudama as a trophy of their prowess, from Arakan to their own capital. The road traverses the indurated rocks at the point where they are actually broadest, and where, in place of having to traverse ridges of highly inclined rocks, the road undulates over a series of spurs, whose ultimate origin must be looked for in the geological structure of the region.

grateful feature in the landscape. The village of Yebile, on the Moo-choung *(choung* or stream) is reached after a pretty sharp descent, and the same rocks as constitute the country traversed are alone to be seen in the bed of the stream.

No sooner, however, is the Moo-choung crossed in a westerly direction than we find ourselves among rocks of an entirely different aspect. These rocks (axials) are not only exceedingly disturbed, and along the boundary especially faulted and crushed, but are also indurated to a considerable extent, and often seamed with calcite. An excellent section of these beds is seen between Yebile and Kondaingzu (near Kondaingkeng of map), and again above that village still going west, in the direction of Pathi, situated on a considerable feeder of the Mahton stream two and a quarter miles from the frontier. The scenery hereabouts is very beautiful, and I know no more wild or picturesque part of Pegu than the Mahton valley near the frontier with its rapid and flashing waters winding between rocky hills clad in virgin forest. From Yebile to Kondaingzu the road lies up the valley and continues up it after passing that village as far as Kyoungtha, where it somewhat abruptly commences to ascend the lofty ridge east of Pathi. From the top of this ridge whose eastern slope is partly cleared for cultivation a magnificent *coup d'œil* is obtained displaying in panoramic order the lower ranges to the eastward and the more imposing and densely wooded ranges with their grassy peaks, west of Pathi. Of these the most conspicuous are Kyeedoung and Bomadoung which respectively mark the culminant points of the eastern and western Arakan range, though, strictly speaking, Bomadoung stands a little out of the general line of the range on a lofty spur, which stretches towards the Kyeedoung or eastern range, but separated from it by the deep gorge-like valley of the Mahton. The Arakan range in fact here bifurcates some four miles south of Bomadoung which is given off to the eastward, and of which the Kyeedoung range may be regarded as the continuation across the Mahton valley, whilst the westerly branch, or main range, after curving back a little runs north through the lofty peak of Myeen-ma-toung above the frontier. On the frontier the eastern and western branches of the range are eight and three quarters miles apart measuring from the Kyeedoung peak to the triple boundary of Birma, Arakan and Pegu. The Kyeedoung and Bomadoung ranges are not only higher than those to the eastward, but unquestionably more densely wooded on their slopes,—and more so I think than is usually the case even on the main range further to the south,—though their summits are in many places covered with tall grass, which gives them rather a tame appearance. I do not think that this great contrast between the vegetation and forest of these hills and of the outer ranges depends to any appreciable extent on the rocks composing them, but results from the injurious influence of hill cultivation as practised in Pegu, the initial step in which is the extirpation, as far as practicable, of all vegetable life over large tracts of hill side from which only a few crops of cereals or other produce will be derived, when the same process will be repeated over some neighbouring area. In the ridge east of Pathi we find an example of the incipient effects of the above process, which has as yet not gone the length necessary to produce the arid and meagre jungles of the outer ranges; but even here, there is an unfavorable contrast with the more westerly slopes of Kyeedoung and Bomadoung, where, I believe, no cultivation whatever has been attempted, and which consequently retain their virgin freshness, and whose slopes are still refreshed with those perennial rills which disappear before the system of hill cultivation as surely as the clouds of morning before the rising sun. Where water is deficient the character of the vegetation will be largely modified by peculiarities of the soil, especially its hygrometric ones, but under more favorable climatal or atmospheric conditions the influence of the soil is, with perhaps certain exceptions, less perceptible. An instance in point seems to be this very range east of Pathi which is well clad in forest, but consists of harsh grits which *primâ facie* would not seem so favorable to vegetation as the beds of the newer group to the eastward where, for the reason above given, the forests are sparse and arid.

At the village of Kondaingzu an enormous thickness of beds is displayed vertical in places, or with a high dip west by north. The grits and shales are very regularly intercalated, the grits varying in thickness from an inch to a foot. They are hard and of a prevailing grey or bluish color. The coarser beds are white-speckled,—which white-speckling is quite *characteristic of the upper portion of the group;*—and a few of the conglomerates are coarse enough to be termed pudding-stones. The shales are grey, rarely dark and often purplish brown, with a few beds creamy or whitish. The section of these beds continues well displayed in the stream as far as Kyoungtha, with no material reversal of dip, which is generally upwards of 70°, varying between east-by-north and east-by-south. Before reaching Kyoungtha, the dip becomes much less and the beds are seen dipping at low angles in the opposite direction, forming small anticlinal folds, but these excepted, the sequence of beds seems uninterrupted, though the great thickness would render it probable that a fault or two brings in the same beds over again. In this stream I noticed many blocks of limestone well rounded, but too large to have travelled very far, but I could not find the outcrop, neither was it known to the natives. It did not seem to contain fossils, and though at the time I was in doubt as to what group to assign it, a more extended examination of the 'axials' removed all doubt as to its belonging to them. At Kyoungtha the road ascends the Pathi range, but the rocks are not well seen. The prevailing dip is east-by-north, though in some places it is reversed. The prevailing beds are grits, thick bedded with rather glazed and rusty looking surfaces, especially where the rock is coarse and conglomeratic. The whole of the group thus far is much indurated and seamed with calcite, though nowhere displaying metamorphism proper. Directly, however, we cross the stream on which Pathi is situated and ascend the slopes of the range leading up to Kyeedoung, we find ourselves passing over a different description of rock, much of which is of a distinctly metamorphic character. Whilst, however, in places the schistose character is plainly developed, the general impress of metamorphism is essentially feeble, and the result ill-defined, and, so to say, spurious. In these softer schistose beds, however, quartz veins have replaced those of calcite, which occur in the grits of the opposite hill; a peculiarity one would hardly have anticipated, *viz.*, that the silicious grits be veined and seamed with calcite and the more argillaceous ones with silica, but I could not satisfy myself of any definite relation between either description of veins and any particular zone of rocks. A more extended knowledge of the axials, however, shows that, whilst a more perfect exhibition of metamorphism than any here seen occurs locally in these beds, such portions do not constitute or belong to another group, how dissimilar soever in character they may be, and this is nowhere more indubitably manifest, than where the metamorphism has been most marked. Such a case, for instance, occurs in the Illowa stream above Yuathit, where a dyke of serpentine crosses the stream, and in contact with which several beds of the axial group assume quite the aspect of a hornblendic schist. A similar case on a somewhat larger scale is seen on the outer or eastern flank of Bidoung,— a huge hill of serpentine a few miles from the frontier,—the protrusion of which seems not only to have affected the axials in its vicinity, converting them into chloritic and diallagic slates, but by its mechanical action to have caused the great outcurving or deflection which the axial boundary here displays. Metamorphism, however, of this distinct character is always very circumscribed in its range and not so likely to mislead as the more subdued type, affecting a great thickness of strata as in the Kyeedoung range for instance; but whilst only speaking of this metamorphism as differing in degree, I do not consider it by any means established that the cause in either case is one and the same; and whilst referring the more local and exceptional action to the direct and immediate agency of the serpentine, I think it very questionable if that rock has been more than indirectly connected with the feebler and wider spread alteration to which the whole group may be said to have been subjected: the serpentine itself possibly being nothing more than the extreme product of the very forces which have induced the feebler but more widely spread alteration in the beds of this group.

The following section in the Hlowa stream above Yuathit will give a good idea of the general character of the upper portion of this group, though its upper limit is rather doubtful:—

Section of the axial group in the Hlowa stream above Yuathit (ascending)—

Lower Axials.

Dark and greenish flaggy shales.
Sandstones and shales.
Dark thin bedded shales with carbonaceous markings.

Upper Axials.

		Ft. In.
a.		
Thick bedded shales, passing into dark massive arenaceous shales with hard nodules interspersed, with *Cardita* (?), &c.		10 0
b.		
Dark blue shale with a few sandstone bands	17 0	
Rubbly limestone conglomerate with a little blue shale, bedding rather indistinct	10 6	
Hard coarse conglomerate with a little fine sandstone	5 9	
		33
c.		
Shales and sandstones in thick and thin beds	188 0	
Fine thin bedded grey argillaceous sandstones with shaly partings ...	34 0	
Do. thicker bedded	4 6	
Thick bedded sandstone in one and two feet beds with shaly partings	63 0	
Coarse hard sub-porcellanous grit	5 0	
Thin bedded shales and sandstones and one six-inch bed	68 0	
Conglomerate	3 0	
Shaly beds	21 0	
Hard argillaceous sub-porcellanous sandstones	102 0	
Shaly beds	102 0	
Massive argillaceous sub-porcellanous sandstones	34 0	
Shaly beds	21 0	
Hard sub-porcellanous sandstones	3 0	
Shaly beds	5 0	
Massive thick bedded grey, white speckled grits	25 0	
Do. but in thinner beds	129 0	
Shaly beds	25 0	
Thick bedded sub-porcellanous white speckled grits	43 0	
Do. but thinner bedded	12 0	
Dark shales and sandstone	51 0	
Bluish grey sub-porcellanous sandstones	21 0	
Dark sandstone and shales	129 0	
Dark shales	45 0	
Creamy blue sub-porcellanous sandstone	5 0	
Sandstone and shales (ill seen)	215 0	
Massive white speckled grit	11 0	
		1,364 6
d.		
Shales and sandstones in from 6- to 18-inch beds	475 0	
Massive greenish grey sandstone	4 0	
Shales with a few thin sandstone beds	172 0	
Shales with a few thick beds of sandstone	475 0	
Sandstone with a few shaly partings	43 0	
Very massive blue and grey sandstone	52 0	
		1,221 0
		2,728 9

	Brought forward ...		2,728 9
e.			
Dark harsh shales and dark thin bedded grey sandstones, none over 4 inches in thickness ...	...	154 0	
Massive argillaceous sandstone ...	...	5 0	
Dark harsh shale and sandstones (as above) ...	...	319 0	
Do. but thicker bedded ...	...	25 0	
Do. but thinner bedded (as above) ...	...	129 0	
Shales and sandstones ...	...	341 0	
			976 0
f.			
Pale massive sandstones gritty and in places finely conglomeratic	...	103 0	
Pale sandstones gritty, grey and creamy and thin bedded ...	...	12 0	
Do. very massive ...	...	6 0	
Hard grey sandstone ...	...	26 0	
			147 0
	TOTAL ...		3,851 9

At or near this point the junction of the nummulitics seems to come in, but this is not very clear, and it may be in reality a few hundred feet higher. A measured thickness of nummulitics now offers of ... ... 1,810 feet.

followed by an estimated section of ... ... 2,307 „

or fully 4,000 feet of nummulitics ... ... 4,117 feet.

The following epitomises this section :—

Ascending.

			Ft.	In.
Lower 'axials' (shales, &c.) seen, more than		...	300	0
Upper 'axials.'	*a.*—*Cardita* (?) shales ...	...	110	0
	b.—Limestone shales, &c.	...	33	3
	c.—Freckled grits, &c. ...	...	1,364	6
	d.—Shales and sandstones	...	1,221	0
	e.— Do. do.	...	976	0
	f.—Sandstones and conglomerates	...	147	0
			3,851	9

The Nummulitic section I shall give elsewhere, but as the upper beds of the group are not represented in it, the entire thickness of this group cannot be safely placed at less than 6,500 feet, and as the lower axials are, I think, thicker than the upper, 8,500 will hardly be an overestimate for that group, giving a total thickness of about 15,000 feet of beds throughout which fossils are so rare as to be practically of no use in sub-dividing so unmanageable a mass of strata or correlating even neighbouring sections. In spite of these drawbacks, however, the above section is valuable from the great thickness of beds exhibited without any reversal* of dip, and by its seeming to embrace the greater part

* My colleague, Mr. Fedden, in noticing this section, speaks of "something very like a fault," but his account is too meagre to be of much use in fixing the spot, and his section only embraces 800 feet of beds in all. He also speaks of the beds "rolling and dipping in various directions," which, I consider, conveys an inaccurate idea, if thereby any reversal of dip is implied, and again where he continues "doubtless these are a repetition of the former beds." It is true that the great thickness of beds here seen dipping with very general regularity, a little troubled in places, but nowhere reversed, would suggest the idea of faulted repetition of the same beds, but there is nothing in the beds themselves to countenance this. I do not think there are any faults cutting through the beds of the section given by me, and they alone could affect the question. Reversal of dip there is none also, and there only remains the question of obliquely folded beds. For this the group seems to me too thick. It is possible to conceive such a cause for the excessive thickness here displayed by some of the groups of shales, but then they appear to be in perfect sequence with beds which certainly have not been thus folded, such as the characteristic white speckled grits. It will be noticed that I have grouped the section into divisions; now, each division taken by itself presents a certain uniformity of facies and type, which in some instances might possibly result from the excessive plication of a comparatively small group of beds, but where these large groups of varied character follow one another, such a supposition is no longer tenable, and the only result is the conclusion that the entire section is a *bonâ fide* display of thickness,—a conclusion borne out by our knowledge and observation of the entire group elsewhere.

of the upper divisions of the axials, which is better defined than the other by the mineral peculiarities and appearance of some of its beds.

The section commences in what I have termed the 'lower axials,' an arbitrary division, but useful in dealing with so vast a group. These lower beds are entirely unfossiliferous as far as my knowledge extends, excepting perhaps obscure carbonaceous markings, or what may be annelid tracks, in some of the shales; at the same time, however, I cannot but think that they may yield some organic remains when more closely studied, and perhaps their lower beds brought to light, for at present I am ignorant of what constitutes the base of this group. They consist of shales and sandstones devoid of any marked character or distinctive beds and usually more or less harsh and indurated. The shales are mostly dark, grey, harsh, and meagre and comminuted or splintery from the pressure they have been subjected to; and it is along lines of crushing and faults, brine springs seem to rise accompanied often by an increased amount of induration of the beds in the neighbourhood. I cannot offer any estimate of the thickness of this division, but as it is nowhere cut through on any of the heavy sections in the Arakan range, its thickness must surpass that of the upper division, so that between 4,000 and 5,000 feet may be provisionally adopted.

The bed, or rather group of beds, which I have made the base of the upper division of the axials, has the advantage of affording what few fossils have hitherto been noticed in them, and of containing a limestone which serves over a great stretch of country as an unfailing indication of a particular horizon, whereby we are greatly aided in determining the relations of other beds also. Many other beds of this division likewise are very well-marked lithologically, so that where the limestone is not seen, we are still able to recognize the upper axials from some of these beds. Such, for instance, are the white speckled grits and pale or creamy sub-porcellanous grits and conglomerates, which form a strong contrast to any rocks either below them or in the upper or nummulitic group against which they occur. At the base of the upper group (just below the mouth of the Thayet stream in the Hlowa section) lies a considerable bed of dark shales, massive and arenaceous, characterised by a *Cardita* (?) which occurs in it rather plentifully, not unfrequently both valves being united. A few small and not well preserved *gastropoda* also occur, but the prevailing and characteristic fossil is the *Cardita;* a little above this occurs the limestone above referred to. It is here a rubbly rock mingled with conglomerate and shale, and forming a sort of composite bed, part limestone and part conglomerate and shale. From this spot (Hlowa stream) I extracted the first *Echinoderm,* and here I could find no other specimens; elsewhere, however, where the limestone was better developed, the species was not rare. Where well-developed this limestone is a homogeneous fine-grained rock, with a conchoidal fracture, and usually of some pale, or dark grey, or bluish, hue. In some spots (as south of Nattoung in feeders of the Thannee Choung) it occurs of various shades of pink and yellow, and I have noticed it converted into a coarsely crystalline white marble. In the Hlowa section I only noticed one bed of this rock, but to the south several minor beds seem to be developed about this horizon, whilst the bed in question itself assumes more important proportions.* This limestone can be traced at intervals along the outer or eastern edge of the group as far as it has been examined. Commencing near the frontier, loose blocks occur in the stream near Kondaingzu, though I did not detect the outcrop. It is again met with near the Mahton about one

* After the experience of the axial group acquired during the past season's work, I think there is little doubt that the Gwa limestone and associated conglomerate and much of the other limestone towards the southern extremity of the range will prove identical with this bed. This will be interesting, though its occurrence on the western slopes of the range materially diminishes the probability of our perfecting our knowledge of the lower portion of the group, as it would seem to indicate that the whole range forms a sort of huge anticlinal in its ensemble, and that the base of this group is nowhere exposed.

mile north-west of Lepangaing where it seems to strike west-south-west. Three miles north-east of this spot is a large patch of limestone forming a low ridge, and two and a half miles south of the first locality is another large mass forming the summit of a hill. The relations of this limestone are not seen, but the ascent to it lies over typical upper axial grits and shales with a high dip east-by-north to east-north-east. These three outcrops are, I think, all disconnected portions of the same bed, the great disturbance of the beds hereabouts being probably produced by the presence of the great serpentine mass of Bidoung hill six miles to the north-west.

Six and a half miles south of Lepangaing, the limestone is again seen in the section above given, where it appears to be unusually thin and poorly developed, but thickens again to the south in the Pemyouk stream and on the ascent to Shue-doung, and in two or three places in the Made (Mudday) stream where it is much disturbed.

(North of Nattoung, and about one and a half mile south-west from Thabiegaing, a limestone is seen on the crest of a low hill, very similar to, though differing from, any of the beds in the neighbouring series. From this spot I obtained a single ill-preserved valve of a *Halobia*, which is very closely allied to, if not identical with, *Halobia Lommeli*, as determined by Dr. Stoliczka. This would indicate a triassic age for the rock in which it occurs, but the relations of this could not be satisfactorily traced.)

Still going south, the limestones referred to above occur at intervals, and display a distinct tendency to approach the boundary of the group. At one and a half mile south-south-east of Nioung-jadouk, it occurs on a hill top very close to the boundary, and still closer to it, above the village of Quienhla (Kwenghla) five miles west-south-west of Akouktoung. In a word, as we proceed south, the Nummulitic boundary cuts back into the axial group, until a little below the parallel of Akouktoung the great and characteristic series of upper axials has almost entirely disappeared, very gradually certainly, from the oblique angle at which the boundary intersects the strike of the beds. The complete elision of this upper group to the south is well seen at Chinuagi (Kyeng-yua-gyee) three miles south-by-west from Quienhla. The stream above Chinuagi seems to display mostly shales of the lower group, and just south of the village in the bed of the stream highly altered sandstones come in of the usual harsh character of so many beds belonging to this portion of the group. Not thirty yards below them comes in quite unaltered a calcareous sandstone profusely charged with Nummulites. The boundary is here fixed within a few yards and strikes through the centre of Chinuagi village, and at this point would seem to completely cut out the whole upper group.

Above the limestone occurs an enormous series of sandstones and shales, which in the section previously given, I have sub-divided into small groups. The lowest of these (*c*) is over 1,300 feet in thickness, and contains a number of very characteristic beds, such as white freckled grits* and conglomerates, not usually very coarse, though now and then coarse beds, almost breccias, are seen, and cream-colored argillaceous sandstones sub-porcellanous, and sometimes offering a 'lithographic' look. Small white quartz pebbles abound in the finer conglomerates, but the coarser conglomerates are mainly composed of fragments of argillaceous subschistose rocks which suggest the idea of their derivation from beds of the lower group. The coarsest beds I anywhere noticed occur in the Shu (Shoo) Choung above

* My colleague, Mr. Fedden, in describing these rocks in the Made valley, on the ascent to Shuedoung and elsewhere, has given emphasis to this peculiar character of *white speckling* in some of these beds by terming them 'a porphyry or altered grit.' The term "porphyry" is of course inadmissible, though the beds often greatly resemble a porphyritic trachyte, and it is clearly to their external aspect only that Mr. Fedden refers when using the term.

Sabatan. In the lower part of the Shu an enormous thickness of beds is fairly exposed, but greatly disturbed and faulted; hence the junction of the Axial and Nummulitic group is not clear. Higher up the stream the dip is more regular, varying from north-east by east to east-north-east, but always high. Some of the sandstones are hard and have strings of quartz pebbles irregularly disseminated through them, and sometimes the pebbles constitute bands through the rock. In one instance I noticed a quartz boulder in one of these conglomeratic sandstones, 6 inches in length, among the finer constituents, but such a case is rare. Some of the coarser beds, however, on this stream tax my power of describing adequately. The most remarkable was a little below a spot where a wall of rock makes the channel almost impassable, a sandstone, with here and there huge angular schistose fragments embedded in it. I satisfied myself that the fragments were really derivative and not the result of any segregative process in the rock itself. Some of these angular pieces very little worn by attrition were more than a cubic foot in content. I have not noticed any similar bed elsewhere, and it is probably local as respects the peculiarity of its included fragments. The general variety of coarse conglomerate is that of a rock mainly composed of partially rounded or well-rounded fragments with very little matrix, in some instances verging on a breccia in aspect and origin, but these beds are local and exceptional, though perhaps belonging to the upper group and characteristic of it.

Above the last group (*c*) occurs a vast thickness of beds which I have sub-divided into three groups (*d, e, f*), all of which occur in uninterrupted sequence, but each possessing a certain appearance which distinguishes it from the other. In the aggregate the thickness of these groups is over 2,300 feet. But though it is tolerably certain that the whole of these belong to the Axial group, it is not equally certain that none of the beds included in the Nummulitics do not belong to the former group, as from their disturbed condition the beds themselves do not give very precise ground for drawing the line between the groups with exactness.

I shall now pass to the consideration of the imposing hill of Shuedoung at the head of the Hlowa valley, returning to the remainder of the Hlowa section when describing the Nummulitic group.

Shuedoung or Shuaylounggyee, situated fourteen miles south-west from Mendoon, is one of the most conspicuous and picturesque hills in Pegu, not so much from its actual height as from the abrupt way in which it rises from among the lower hills which encircle it, and from the exceedingly rugged and precipitous character of its outlines.

It is situated between the sources of the Hlowa and Pemyouk streams, and marks a remarkable change in the Arakan range, of which in some respects it is the culminant peak. Instead, however, of the range continuing its course northward past Shuedoung, it here takes a sharp sigmoid curve to the westward, before again trending north; giving thereby the appearance to Shuedoung of standing out from the main range like a promontory round which the sources of the Hlowa wind, so that the drainage pertaining to the Pegu side of the mountain, received by the Hlowa and Pemyouk streams, represents an arc of no less than 300 degrees at least, with the hill as a centre. The hill itself is a ridge of 'axial' shales and grits, much indurated and culminating in a serrated cluster of rugged pinnacles. The prevailing strike of the ridge corresponds with the normal strike of the axials, and is about north-north-west, and viewed from the north the bedded structure of the rocks composing the hill is plainly perceptible, but from an easterly view the hill presents all the appearance of being composed of some granitic mass, so sharply curved and defiant are its tor-like crags. The ascent is effected over two long spurs, one to the north, running down into the Hlowa stream, the other to the south into the Pemyouk, my colleague selecting the latter whilst I ascended by the former route. From my colleague's account of his ascent from the south, it is abundantly clear that the beds on that side are higher in the series than those on the

other, and that a local change in the direction of the beds has occurred, as his account reveals, circumstantially enough, the characteristic beds of the upper axials, whilst to the north these beds are replaced by shales of the lower group. A great deal of disturbance here occurs, resulting no doubt from the sharp bend and dislocation as regards its general bearing which the range has here undergone, but the mineral character of the rocks sufficiently indicate their general relations. On the south side, my colleague records, 'shales, and a bed of argillaceous impure limestone,' also 'fine grained speckly white, and green, rock,' and on the summit a porphyritic or altered grit. On the ascent from the north by the Hlowa stream, we find none of these beds, which, however, are seen in the Hlowa, lower down where my section is taken, but in their place at the point where we quit the stream bed, indurated shales, dark and harsh, such as mark the lower group. Higher up the ascent, softer shales are passed over, and at the highest point gained by me, a sort of ridge running down from and in the line of strike of the northern extremity of the hill, indurated grits not very well characterised. There was throughout these beds a somewhat notable scarcity of quartz veins, which, in such a focus of disturbance, I should have expected to find more developed. My colleague found serpentine in profusion, but on the Hlowa spur there was none excepting a very insignificant patch, like a dying out vein, on the summit. No trace of serpentine is seen in the Hlowa where the ascent commences, so that no considerable development of this rock occurs on the northern flanks of the hill, how common soever to the south; and this distribution of the serpentine tallies with many observations elsewhere, that the serpentine seems to affect a certain geological horizon, namely, that of the upper axials, but occupying a low position in them. It would convey an erroneous view to describe Shuedoung as the culmination of the line of serpentine outbursts running up from the south-south-east, since, waiving the remark that Shuedoung is not a serpentine outburst at all, I would observe that though Shuedoung may be described as a somewhat abnormal culminating peak of the Arakan range, yet it, from that very fact, does not lie within the 'line of serpentine outbursts' properly so called, which generally occur within the outer ranges. Serpentine occurs in Shuedoung, and this is the only instance yet known to me of that rock occurring on the actual watershed of the range, the line of serpentine outbursts usually traversing the outer hills. This deviation from its usual position in the hills seems accounted for in part by the fact before alluded to, that it seems to follow not so much a geographical zone of country as a certain geological horizon. This horizon, a low one in the upper axials, very exceptionally crosses Shuedoung; the main range more usually being solely composed of beds far lower in the series; hence, the presence of serpentine on Shuedoung is not at variance with its relations elsewhere to the surrounding rocks, though not on the 'line of serpentine outbursts,' (if we generalize these phenomena,) the general strike of which line corresponds with the general strike of the adjoining beds.

In strong contrast with the Hlowa section is that seen along the line of the Arakan road. The breadth of the axial group at Shuedoung is barely seven miles, and most of the beds on this line belong to the upper division of the group. At Thabie Sukan on the Arakan road, the breadth of the group is over 20 miles, of which not a fifth belongs to the upper division. Here then, we might expect a fine section of the lower group, but the value of this section is inversely in proportion to the length of ground it covers, and we see great complexity of dip and undulations of strata without the instructive section displayed in the Hlowa. In addition to which must be added the absence of any fossiliferous bed or marked mineral group in those lower axials to enable us to divide or classify them.

I will here describe the mode of occurrence of the serpentine and its relation to the rocks I am now treating of. Serpentine, though widely distributed, nowhere occurs in patches of very large extent, if we perhaps except the Bidoung hill. It occurs in two ways, which may be conveniently considered separately (though perhaps the main

distinction between them is merely one of degree) that is, in detached outbursts assuming the proportions of low hills, and as veins or dykes traversing the 'axial' strata. The most important development of this rock, throughout the country north of the parallel of Akouktoung, is the Bidoung hill, five miles south by east of Pathi. This serpentine area is five miles in length by from two to two and a half in breadth and is divided by the Mahton: Bidoung standing on the west side, faced on the east by a hill of hardly less height. These two hills indicate the great bulk of the serpentine along an axis stretching north by east, but from the easterly hill a small range runs nearly due south impinging on the Mahton at Keinggye, though the serpentine stops just short and is not seen here in the river. This most important development of serpentine illustrates the remark I have before made of that rock affecting the outer rather than the central hills. Descending the Mahton from the north, Bidoung hill is seen straight ahead of the river channel, and so distinctly is the bulk of Bidoung dissociated from the spurs of the main range, that without reference to the map, it is doubtful which side of the hill the Mahton is about to flow, but on reaching the hill it flows round its east flank through one of the prettiest gorges conceivable. The character of the rock is proclaimed by the stunted vegetation covering it, but where cracks have allowed the retention of moisture, trees, especially the Thitsi *(Melanorrhœa usitatissima)*, have taken hold, favored of course by the generally cooler and moister air of the country close to the densely wooded main range. Large surfaces of rock, however, are absolutely and in the most literal sense bare of all verdure and impart a distinctive character which, once seen, cannot be mistaken. I have already remarked on the metamorphism developed among the 'axials' on the flanks of Bidoung, but the intrusion of this mass of serpentine seems to have produced even a greater mechanical result, in the deflection of the axial boundary here to the eastward. The boundary is not perhaps so sharply defined as in some spots, but I regard the channel of the Moo stream as very nearly coinciding with it, or in fact resulting from it. South of Lepangain, too, the boundary seems to find physical expression in the conformation of the surface, but for a few miles east of Lepangain the boundary is obscure, and few rocks are seen through the jungly undulating country which intervenes. The fact of the general outward deflection of the boundary is not, however, in the main affected by a little ambiguity in detail, and the *curve so corresponds to the great mass of Bidoung serpentine*, that taken together with the excessively disturbed condition of the rocks hereabouts, we are forced to regard the cause of these appearances as nothing more nor less than the mechanical intrusion of that hill mass.

The next considerable development of serpentine occurs as a low narrow ridge of some three miles in length intersected by the Made stream, and situated on the junction of the axial and nummulitic groups. This ridge, which must often be less than the third of a mile in breadth, seems as though it were a huge dyke or wall of rock occupying at this spot the boundary itself. Above it very considerable disturbance exists among the axials, and enormous masses of the limestone are seen in the bed of the stream, much affected both chemically and mechanically. This action is not so well, if at all, noticed in the nummulitic group, and whereas the upper axials are repeatedly seen thus altered, I do not remember any similar amount of metamorphism in the nummulitic group, though here it is contiguous to a very considerable mass of serpentine which has characteristically affected the lower group.

The next considerable mass of serpentine is that which constitutes Nattoung a prominent hill between the Made and Thanni streams. The rock here rises into two peaks, that of Shinbaian to the north-west and the somewhat higher one of Nattoung to the south-east, giving a length of about three and a half miles in its long axis.

Two miles west of Laidi on the Thanni channel occur two small patches of serpentine forming the twin peaks of Thitsidoung and Hnordoung. These patches are separated by

'axial' strata, but midway between them like a link is a very minute patch of serpentine of a few yards in diameter, probably a dyke. Thitsi hill is in fact a miniature of Nattoung, as Nattoung is of Bidoung, and no other similar outbursts are known to me within the area under review. All the other localities seem to fall under the category of veins subordinate to the axials they traverse, but be they all connected or not, the rock throughout is one and the same whether occurring in veins or developed in masses like Bidoung. Serpentine veins are far from infrequent in the upper axial zone, and I rather think they are confined to it, or to within a short distance of it. Certain it is that I can recall no instance of their occurrence in the older division of the group, or where the upper group is not present likewise. The horizon indeed which these veins seem to affect is one near the bottom of the upper axials, and we are pretty certain to find the characteristic limestone of this division not very far from the outcrop of serpentine. The limestone is frequently altered and sometimes only occurs sparingly, but it is usually to be seen, or some other of the equally characteristic beds of this horizon. The veins are always small and usually associated with a species of steatite from which the Burmese manufacture pencils for writing on black boards. I cannot affirm that this steatite is always associated with serpentine, but such is the case usually. This steatite is called 'kangu' and is largely imported from Upper Burmah. There are, however, numerous places in Western Prome where it occurs and where it is extracted for local use. It usually occurs in small pieces lying loose in the decaying rock and not commonly in pieces larger than a hen's egg. It occurs in shale (and also far to the south, as noticed in a previous report, in sandstone) and appears to be the result of a segregative metamorphism. It is not an intrusive rock or mineral and yet its component atoms must have enjoyed complete mobility, and its formation seems due to the re-arrangement of the constituents of certain beds of the axial group, through an influence which may have resulted from the presence of serpentine veins in the vicinity, for there seems a decided connexion between the two.

A curious variety of this rock is sometimes seen closely simulating a conglomerate. The dark steatite occurs in various sized nodules or amygdala, from the size of a hemp-seed or less to that of a small egg. These nodules are smooth and burnished and impacted in a matrix of white fibrous quartz, in just sufficient quantity to separate the nodules of steatite, but still forming a very inconsiderable proportion of the rock. Excellent samples of this variety occur on Shinbaian hill, and here I could detect no instance of the steatite enveloping any portion of quartz, but where the two minerals are more equally proportioned I believe either indifferently envelopes the other. The mineral occurs of various tints from pale grey to black, the paler varieties being esteemed the purest and most suitable for writing. The very dark varieties approach a shale in character, and may be regarded as peculiarly altered shale: some pieces display very distinct fissures or shrinkage cracks, and all the appearance of having been once in a plastic state.

At Shinbaian hill just on the flanks of the serpentine, or before that rock is quite reached, a considerable quantity of the above varieties is developed on the hill side and also a more massive or compact variety than is usually seen. This variety occurred in regular strata of from 6 inches to a foot in thickness, but unequally developed. The more massive portions broke with a clean but earthy fracture, and dull surface, and much resembled in general appearance a claystone; but this dull variety passes into the ordinary sort with highly lustrous surface planes and the quasi foliated structure as seen in pure spermaceti; and the association of the two suggests that the latter merely consists of the finer portions eliminated by segregation from the other. The common shape for the finer sort to spontaneously break up into or arrange itself is that of rudely amygdaloidal pieces, with curved ends, either the result of pressure, or of some modified form of crystallization. The highly

burnished surfaces which traverse the rock might seem to indicate the former cause and in appearance certainly resemble the 'slicken sides' in a coal shale, but the peculiar arrangement of the steatite amygdala and their enveloping layers of quartz strongly contra indicates this idea, as there is no crushing or subsequent re-cementing of these brittle quartz layers, as would be seen if the burnished surface of the included nodules were due to pressure. Pressure has then nothing to do with the production of the smooth surfaces traversing the finer sorts of the steatite and displayed on the surface of its nodules, and the phenomenon is due to some peculiar form of segregative action whereby the nodules themselves originated from the finer portions of the adjacent rock. I think I am warranted in regarding this steatite as a mineral species, although it sometimes exhibits a passage into a form to which that term might be less applicable. Some of the largest lumps of the compacter variety of the mineral are pale grey distinctly tinged with pale yellowish or leek-green, or perhaps rather green than grey, lustre rather waxy, and decidedly tough, especially in a direction across the polished foliation planes which are rarely absent in the mass.

The serpentine is everywhere very uniform in appearance, but in some spots, as west of Laidi, a rock is associated with it like an ordinary greenstone. I think it not quite certain that this rock is not an altered one, or if not a bedded rock or shale altered, I should regard it as a variety of serpentine produced by the reaction of the bedded rocks on it; my reason for so judging being the trifling and insignificant development of it, its obscure relations and the unlikelihood of a mere patch of rock of this character appearing here and there in the merest indications, if not a part of, and subordinate to, the general serpentine effusion in the neighbourhood. Nowhere else does this trap rock appear as an independent formation, but merely here as a very feebly developed satellite of the widely diffused Serpentine.

Sketch of Geological structure of the Southern Konkan, *by* C. J. Wilkinson, Esq., *late of the* Geological Survey of India.

The South Konkan is in its northern part composed of trap rocks, covered to a varying distance from the sea by laterite. Where the latter rock is present it gives a monotonous aspect to the country, forming an undulating and in some places quite flat plateau, the surface of which is a sheet of rock, black and slag-like externally. This laterite plateau, which has a general elevation of between two and three hundred feet, has a bare black appearance, supporting no vegetation, except scanty grass and stunted trees here and there. There are places where the rock has been denuded, and here owing to the presence of thicker soil, the ground can be cultivated.

It is cut through by numerous rivers, the largest of which rise in the ghâts, and after flowing through comparatively open trap country, enter the laterite through deep ravines, which widen towards the sea, the rivers becoming broad tidal creeks. In these ravines, along the banks of the rivers, villages are generally situated, and every available spot of the rich alluvial soil is cultivated for the production of rice and other grain. At the sea coast the laterite forms bluff cliffs, in the lower part of which trap is disclosed.

At Rutnagherry, &c., in well and other sections, the trap is found to be overlaid by a thickness of a few feet of white clay, imbedding fruits and containing thin carbonaceous seams composed for the most part of leaves. This is separated from the soft laterite above by a ferruginous band about an inch thick, having much the appearance of Hæmatite. It

is vesicular, the cavities being filled by quartz, &c. The soft laterite soil above hardens on exposure and this rapidly. It is very thick here and along the sea coast, trap only becoming disclosed in the deep sections and at the base of the cliffs. In proceeding inland, however, it is found higher up in the hills, which seems to show that it has a westerly dip, though it is very difficult to determine the amount, as all the sections are so covered by the detritus from the laterite. East of Rutnagherry, the latter rock extends for about fifteen or twenty miles; beyond this the trap hills are more irregular in outline and increase gradually in height towards the ghâts. The eastern boundary of the laterite runs west of Lanje in a south-east direction, passing east of Rajapur to Khareputtun. South of the latter place its direction has been more correctly determined.

About Phonda it is found nearer to the ghâts than in other places, it then bears to the south-west, meeting low trap hills which run out from the ghâts at the north of the Sawunt Waree state. The lower beds of this pass under it about half way between the ghâts and the sea. South of this the width of the formation becomes much less, and it extends as a band ten or fifteen miles wide along the western boundary of the state and in the narrow strip of British territory by Vingorla, &c.

It occurs in great quantity in the Goa territory. In speaking of the laterite boundary, I refer to that of the plateau which has a very constant elevation, and consists, as I have mentioned, of a series of flat-topped or slightly undulating hills separated from one another by deep ravines, which have been excavated by the rivers which drain the country.

There are numerous instances where this rock occurs further east, forming patches which in many cases may be outliers of the great mass, though oftener occurring at a lower level, being the products of the denudation of the older laterite. These often have the appearance of true laterite, but are more generally found as gravel, sandstone, conglomerate, &c.

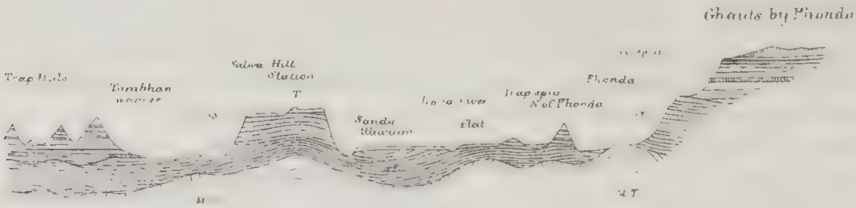
The country east of the laterite boundary is more varied in aspect. The rivers rising in the ghâts run westward between lofty spurs for some miles, and then emerge into lower and more open country, which continues up to the scarped edge of the laterite hills. These spurs in the northern part of the district consist entirely of trap, the lines of flow of the beds in them being generally easily traceable, and merging at their eastern extremity into the main range of the ghâts. These beds having been irregularly denuded, the result is, that conical peaks have been left, which vary the otherwise even outline of the hills. These peaks are generally surmounted by a sharp black point of rock. A good example of this occurs in a spur south of Phonda which runs out westward from the ghâts. In the peaks on this, portions of a thick bed of black columnar basalt are seen, the bed of which these are outliers being very conspicuous in the ghâts themselves.

The metamorphics, &c., skirting the southern boundary of the trap are at a low level generally. The rock immediately under the trap is a white, yellow or pink altered sandstone, associated with shales and lying unconformably on the older metamorphic rocks.

The evidence tends to show that this sandstone formation was originally much thicker, but it was much reduced by denudation before the outpouring of the trap, and this thinning has subsequently been carried on still further by other denudation affecting both it and the overlying rock.

About Phonda and the country to the west, this sandstone (quartzite) is well seen, forming an open patch of country about ten square miles in area and enclosed within the trap boundary, this rock with the exception of one or two isolated masses having been entirely denuded.

In the north-west corner of this sandstone area there is a group of hills, of which one, Salwa hill, is about eight or nine hundred feet high. The arrangement of the beds in the main mass of the hill is difficult to determine, as the sides are thickly covered with detritus



Sketch Section of Salwa and adjoining hills in Southern Konkan.

and jungle, but at the western base shales generally associated with this sandstone occur, dipping slightly to the west and passing under the trap at its boundary, whilst the summit of the hill is formed by a thick bed of sandstone pink in colour, and either horizontal or perhaps with a very slight dip westward. There are other high hills or spurs on the edge of the ghâts formed of sandstone lying on metamorphics which are partially disclosed and capped by the same thick bed of sandstone, here dipping eastward, the two portions of the beds on the respective hills being apparently the remains of a low anticlinal axis. The parts of these beds which intervened have been swept away, possibly before the trap covered up the country. The first flows of trap poured into the hollows between the hills, for at the boundary of this patch of sandstone the trap is generally found at their bases. As the successive flows of trap surrounded them, the highest ones remained probably as islands in a sea of trap. Finally they became covered up by some of the higher beds, which are now only seen in the scarped sides of the ghâts a few miles eastward. As I have mentioned, this trap with the exception of one or two patches, has since been denuded. The effects of denudation on the trap west of Salwa hill are rather curious, for side by side with this hill, their bases almost touching, is another hill quite conical in shape, and formed entirely of successive beds of trap. The two are nearly equal in height and present a strong contrast to each other, the trap hill conical in shape and almost devoid of vegetation with the lines of flow of the trap showing black and strong, and the sandstone hill, long, flat-topped and thickly wooded.

The country south of this patch of sandstone is covered by a band of trap about ten miles wide. The lowest beds of this are approximately at the same elevation as the laterite plateau to the west under which they pass, but there are lofty spurs running out on them formed of higher beds. When the trap passes under the laterite, it no longer influences the aspect of the country which is now a slightly undulating plateau intersected by deep ravines, in which trap, sandstone, and often the older metamorphics, are disclosed.

The southernmost boundary of the trap bears in a direction west by south along the north side of the valley formed by the Usya Mut (or Kimkaoli) river. From Ramgurh it bears more north-west, and is found down to the sea at Kunkeshwar just south of Deogurh.

In the Usya Mut valley, which is the northern boundary of the Sawunt Waree state, the older metamorphics are disclosed, and from this southward the denudation of the country before the outpouring of the trap appears to have removed most of the sandstone, which conceals the older metamorphics almost entirely more to the north. The metamorphics only

attain a very slight elevation about this part of the country, and outlying trap is found capping them to the south of the valley forming low comparatively flat-topped hills, varied by higher spurs to the east of Kolsooli. This trap also becomes concealed under the laterite, south of Kunkooli (Usya Mut), the edges of the bed (for it seems as if only one bed extended far) being seen in the scarped sides of the laterite hills not far from their summits. Still further south-west and extending almost to Malwun, outliers of trap are found overlying the metamorphics and under the laterite.

South of the trap hills and spurs which are found in the northern part of the Sawunt Waree state, the metamorphic rocks attain a greater elevation, forming lofty spurs in the neighbourhood of the ghâts. The earlier trap flows abutted against these hills, but it was only the higher beds which could have concealed their summits, and as you go south outlying patches are still found capping the great metamorphic ridges, even as far westward as the town of Sawunt Waree, on the hills which surround that place.

In the ghâts the older rocks attain a greater and greater height, and are only covered by two or three beds of a very inconsiderable thickness.

There is a curious example of outlying patches of the highest beds of the ghâts in the shape of small slab-like masses of trap rock left on the most elevated parts of the spurs. These from their almost inaccessible position were long ago chosen as sites on which hill forts were constructed. They are generally separated from the ghâts by a deep gorge. As examples of these forts in the Sawunt Waree state may be instanced those of Rangna, Monohur, Hummutgur, Pargurh, Suda, &c.

The Sawunt Waree state is composed for the most part of metamorphic rocks, but there is at the northern part, as I have mentioned, a considerable quantity of trap, and on the west the narrow band of laterite. These with the ghâts on the east form physical features which serve as a sort of natural boundary to the country. The great metamorphic spurs which run out west from under the mural termination of the Deccan trap at the ghâts, extend to varying distances, and either end abruptly or break into clusters of lower hills. The intervening country is low and covered with thicker soil than is usually the case in the Konkan: this renders the Sawunt Waree state more open to cultivation than the barren laterite plateau to the west and north.

The soil is obtained from the disintegration of the metamorphic rocks, and is light coloured and clayey, though fine sandy soil occurs as frequently, being derived from the quartzite and altered sandstone so abundant in the district.

Along the alluvial banks of the rivers, rice is extensively cultivated during all the fine season, a system of irrigation being established by means of Persian wheels and other contrivances. By these water is constantly raised from the beds of the rivers, and distributed by channels to the different plots of rice ground in the neighbourhood, these fields having been previously prepared. They consist of rich alluvial mud traversed by numerous little channels for the water, crossing each other at right angles. When the country cultivated is inclined at any angle, an arrangement of step-like embankments is constructed, each surrounded by a little mud parapet, a few inches high. The water after thoroughly saturating one field is allowed to escape into the next below, through an orifice cut in the parapet. This system of irrigation is very generally made use of throughout the Konkan.

On the supposed occurrence of Native Antimony in the Straits Settlements, by T. Oldham, *Supdt., Geological Survey of India.*

About the middle of December last, a specimen of a beautiful silvery metallic substance was forwarded to this office from the Home Department, with a request that it might be analysed and reported on. It was stated to have been discovered in the Straits Settlements, but no locality was given.

On examination it proved to be Native Antimony, of great purity, yielding no trace of arsenic or of silver, and only a slight trace of iron and also of sulphur. This was reported to Government, and it was stated that if it occurred in any quantity, the discovery was a very valuable one. A nearly pure mineral like that forwarded would always command a market, and would realize about seventy-five pounds (£75) per ton in England. Enquiry was made as to the locality where found, &c., and a more recent letter from the Secretary to the Straits Government, states, "that it was found on Pulo Obin or Ubin, an island lying at the east end of Silat Tambran, the strait dividing Singapore from the mainland; that a careful search had been made, and a reward offered to any person finding more of the same, but that up to the present time (15th February 1871) no more had been discovered, and that it seemed probable that the specimen received by the Government must have been introduced into the island from some other place as yet unknown."

Native Antimony also occurs in Borneo, Sarawak, &c.

On the composition of a deposit in the boilers of Steam Engines at Ranigunj, by T. Oldham, *Supdt., Geological Survey of India.*

During a recent visit to the Ranigunj collieries, I was struck with the amount and character of the deposit in some of the boilers of the Engines in use there: and was desirous of ascertaining the true composition. By the kindness of A. Stuart, Esq., the General Manager of the Bengal Coal Company, I obtained specimens. The specimen examined by Mr. Tween, Curator of the Geological Museum, was taken from the boiler at a deep pit near Ranigunj known as No. 36. The water, which feeds the boilers here, is all derived from the mine itself, passing from the pump heads through a filtering wall of fine sand, and received in a masonry tank, where a certain amount of fine matter is deposited on settling. This water, as it passes to the boilers, looks bright, clear and pure, has no taste, is hard, but not unpleasant, and altogether looks clear good water. From its use, however, a large amount of deposit results. This is thrown down in a fine almost impalpable powder, which, when dried in the air, is of a light ash-grey tint. Some of this was carefully dried by exposure for five hours at a temperature of 212° Ft., and the dried powder then analysed.

It gave a percentage composition as follows :—

Water	7·2
Organic matter	2·1
Insoluble clay	8·8
Iron and alumina	1·23
Carbonate of lime	47·67
" of magnesia	33·00
	100·00

This shows that the deposit consists chiefly of carbonates of lime and magnesia, which, doubtless, have been taken up from the calcareous and dolomitic sandstones, so frequent in the upper series of the Ranigunj field, by the surface water when passing through these rocks to the bottom of the mine.

The organic matter showed as a slimy dark substance separated on the filtering paper.

As the water comes from the mines, the principal apparent impurities are minute particles of coal-dust, and shale mechanically mixed with it, while it is certain that a portion, at least, of the iron will have been derived from the rusting of the pumps, &c. But it will be seen that more than three-fourths of the whole consists of the carbonates of lime and of magnesia held in solution in the water.

NOTE ON THE PLANT-BEARING SANDSTONES OF THE GODAVERY VALLEY, ON THE SOUTHERN EXTENSION OF ROCKS BELONGING TO THE KÁMTHI GROUP TO THE NEIGHBOURHOOD OF ELLORE AND RÁJÁMANDRI, AND ON THE POSSIBLE OCCURRENCE OF COAL IN THE SAME DIRECTION, BY WILLIAM T. BLANFORD, Deputy Superintendent, Geological Survey, India.

Recent explorations in the Godavery valley below Sironcha, and in parts of the adjoining country, have enabled me to ascertain that a very large area is occupied by representatives of the various formations which have been described in Bengal and the Central Provinces under the names of Panchet, Damúda, and Tálchir. The occurrence of sandstone in the bed of the Godavery and along its banks throughout a large portion of the river's course below Sironcha was, I believe, first made known by Mr. Wall in the Madras Journal of Literature and Science, New Series, Vol. II. It now appears that sedimentary beds belonging to the Damúda group and its associates extend, apparently without a single break* from the neighbourhood of Mánglí and Phizdúra, 34 miles in a direct line north-north-west of Chánda, to Lingálá on the Godavery, just above the top of the first barrier and 14 miles above Dúmagúdiam, or throughout a distance of 200 miles. A break then occurs which extends along the river for about 25 miles. The sandstones re-appear at Raigúdiam, about 6 miles below Bhadráchallam, and thence continue along the south or right bank of the river with one brief interruption for about 15 miles, terminating a little below the village of Mádaváram. These beds, as will presently be shown, extend far to the southwards.

Metamorphic and Vindhyan rocks occupy the bed of the river at the second and third barriers and for some miles below them, the remaining portion of the Pranhita and Godavery are in the soft sandstones and the associated beds, and at both barriers a continuous belt of the later sedimentary formations on the right bank of the river, though at a distance from its course, unites the areas occupied by the same rocks in the river's bed.

Throughout the whole valley of the Pranhita and Godavery† below the third barrier at the spot where the Wardhá and Waingangá unite to form the first named stream, the area occupied by the plant-bearing sandstones on the left (north and east) bank of the river is but trifling, whilst from the right bank these beds extend for a great, but hitherto unascertained distance into the little known tracts of the Nizam's territories belonging to the Rámghir and Kamarmet Sircars, and perhaps into Warangal.

In the same manner the sandstones below Bhadráchallam occupy an area not exceeding 8 or 10 square miles north of the Godavery, while to the south they cover a tract of country 25 miles in breadth from east to west near the river, and gradually becoming broader till it is at least 50 miles across. It extends from the Godavery near Bhadráchallam till it is lost, 60 miles further to the south, beneath the coast alluvium in the neighbourhood of Ellore. To the south-east it stretches nearly to Rájámandri, extending to the banks of the Godavery

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* This cannot be stated positively as yet, some portions of the ground not having been examined. But no break exists exceeding a very few miles in extent.

† The valley of the Godavery proper above the junction of the Pranhita is geologically almost unknown. It is only certain that the greater portion consists of trap.

near Polavâram, below the great gorge in the metamorphic rocks through which the river runs. At Pangadi near Rájámandri the sandstones are covered up by the bedded dolerites of the Deccan trap, just as, 300 miles in a direct line to the north-west, the same sandstones, in the districts of Chanda and South-east Berar, disappear beneath the same traps on the eastern verge of the great basaltic area of the Deccan.

The proportion of the enormous extent of sedimentary rocks in the valley of the Godavery and its neighbourhood, which is occupied by the valuable coal-bearing beds of the Damúda group, appears, so far as research has hitherto extended, to be extremely small. Here and there along the boundary of the sandstone tract, beds are found with the mineral character of the Barákar group of Bengal. Such is the case near Chandá, and the same beds occur at Lingálá, above the first barrier, and at Mádavâram below it; and in each case where these rocks have been observed, coal beds, sometimes of little or no value it is true, have been found associated with them. It is highly probable that further examination will show the presence of these valuable beds in several places where they have not hitherto been detected, but the search is difficult, because the surface of the country in which the sandstones are found is greatly concealed by a thick covering of sandy clay and sand, derived from the disintegration of the soft argillaceous sandstones.

The lower Panchets of Bengal, to which the name Panchet should perhaps be restricted, appear to be represented by rocks of similar mineral character in the Godavery valley, but further examination of these beds is necessary in order to determine their position in the series and their relations to the limestones containing fish remains, which are met with in several places near Sironcha.

The Tálchirs, at the base of the great series, precisely resemble their representatives elsewhere, but the unconformity between them and the Damúdas appears to be greater than usual.

These formations, the Barákars, Panchets, and Tálchirs, together do not take up a tenth part of the area occupied by the sandstones. The great bulk of these consist of coarse argillaceous sandstones and grits of no very marked character, with hard ferruginous bands. The few fossils found in them, chiefly *Vertebraria*, *Calamites*, and *Glossopteris*, are identical with Damúda forms, but the mineral character of the beds taken as a whole is always slightly and sometimes remarkably different from that of any true Damúda beds, as found elsewhere, while the fossil plants seem to preclude the idea of associating these rocks with the Panchets, the flora of which, so far as it is known, is very different. One of the most striking distinctions between these beds and the Damúdas proper is the absence of coal and of any carbonaceous matter in the former, even the plant remains having lost their carbon and existing as mere impressions. It appears, therefore, desirable, both for scientific and economic reasons, to apply a distinctive term to these beds, restricting the name Damúda to the group or groups which usually contain coal. For these reasons, I proposed some years since the name of *Kámthi* beds for some rocks near Nágpúr which belong to this group. The name has since come into more general use on the Survey, and it has become necessary briefly to repeat the reasons for first adopting it. The Kámthi group is intermediate in position between the Barákar and Panchet groups

So far as their geological examination has progressed, the immense mass of argillaceous sandstones which occupy so large a proportion of the country in Chánda and South-east Berar appears to belong to the Kámthi group. The same is probably the case with the sandstones of Sironcha and those on the right bank of the Godavery, which have, however, hitherto remained unexplored. The beds extending south of the Godavery towards Ellore and Rájámandri appear to me to differ in no important respect from the rocks in Chánda.

Sections, except on the sides of hills, are unusually rare, precisely as in the more northern area, and the great mass of the rocks consists of white and brown argillaceous sandstones, grit, and conglomerate, with so little marked mineral character that they might be either Barákar, Kámthi, or Panchet. On the Godavery, below Bhadráchallam, it is very difficult to draw a line between the Damúda and Kámthi groups.

But in the neighbourhood of Ellore and Rájámandri the sandstones are frequently variegated in a peculiar and characteristic manner. They are associated with numerous hard bands of ferruginous grit and compact red and yellow shale. In one instance sandstone was found with a peculiar semi-vitreous texture, which is very characteristic of some beds in Chánda and Berar. All these characters lead unmistakeably to the conclusion that these rocks are the representatives of the Kámthi beds of Nágpúr and Chánda.

Let it not be supposed that this conclusion is a mere abstract scientific matter, interesting perhaps to geologists, but of no importance to the world in general. In reality it involves a most serious economic question. It is quite unnecessary to remark that the discovery of coal in the Madras Presidency is a great desideratum. Hitherto, despite much research, neither coal nor the rocks with which coal is associated in India have been met with in any part of the country south of the Godavery. The tracing, therefore, into the Madras Presidency of sandstones belonging to the great series of which the coal-bearing beds of Bengal form a portion is of great interest and importance, because there is a possibility of the coal-bearing beds being associated with them.* The greater part of the working season of 1870-71 has been devoted to the very important borings for coal on the Godavery, and I have been unable to give nearly sufficient time to the examination of the Ellore and Rájámandri country to enable me to ascertain with certainty the presence or absence of Damúda beds. Indeed, the surface of the rocks, although much better exposed than is the case a little further to the north, is so far concealed that it will probably be necessary to bore in order to determine this question. But although there is fair possibility of coal-bearing rocks being found, I could not positively detect their presence anywhere, and in one or two places, the base of the Kámthis was seen resting upon the metamorphic rocks, all beds of the Damúda group being wanting.

In conclusion I may briefly describe the limits of the Kámthi sandstone area near Ellore and Rájámandri. The northern boundary runs nearly east and west from Raigúdiam on the Godavery to Palúncha. There it turns sharply to the south, and the eastern boundary extends thence at first south, then south-east to Chintalpúdi, 20 miles north-by-west of Ellore. Thence, after making a sweep to the westward, the boundary runs to the south, passing just east of the large town of Núzed (Noozeid or Noozudoo), whence it turns south-west, and finally reaches the alluvial plain of Ellore near a village called Krishnawáram, at a spot nearly 20 miles east-by-north of Bezwárá, and 16 miles west-by-south of Ellore.

Along the southern part of this boundary, near Núzed, the base of the sandstones is well exposed in several places, and, so far as I was able to examine, there was no trace of Damúda rocks. Still, further and closer examination is desirable before the same conclusion can be arrived at for the whole country.

The Kámthi beds stretch along the edge of the alluvium from the point already mentioned east-by-south of Ellore to the Godavery, trap intervening near the latter river at Pangadi, as already mentioned. The beds are in general flat, or dip at low angles.

* So far as I am aware,—I am writing without means of reference, and may be mistaken—the occurrence of these sandstones near Ellore and Rájámandri has not before been noticed.

The eastern or rather north-eastern limit of the sandstone area extends from the Godavery at Pondigúl, 12 miles below Bhadráchallam, through the western portion of the mass of hills which culminate at the trigonometrical station of Rájgota. The boundary passes a few miles east of Ashráopetta, and thence trends nearly due east in the direction of a point on the Godavery a little south of Polavâram. Whether it crosses the river has not been ascertained.

This boundary also has only been most cursorily examined, and it is impossible at present even to guess whether Damúda beds occur along it or not. They are found on the north close to the Godavery, but they appear to be wanting in the hills a few miles further south. Some sandstones were seen near Ashráopetta which had the appearance of Barákars, but it should be repeated that after much experience of the two formations Barákar and Kámthi, I confess myself often unable to distinguish between the sandstones which usually form the bulk of both groups. I can only conclude that further examination of both boundaries, first geological and afterwards by boring, is requisite. This is especially a case in which research, to have any chance of success, must proceed on purely geological principles.

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Specimens of rocks and fossils from the limestone ridges north of the Linzithang plain, from Dr. Cayley.

Specimens of rough jade, and of a rude stone-mortar, small wooden wedges, &c., found in the now abandoned jade quarries opposite Gulbasha, from Dr. Cayley.

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REPORT ON THE PROGRESS AND RESULTS OF BORINGS FOR COAL IN THE GODÁVARÍ VALLEY NEAR DÚMAGÚDEM AND BHADRÁCHALAM, *by* W. T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey of India.*

The occurrence of fragments of shaly coal in the bed of the Godávarí close to the spot where the Tál river joins it from the north, about twelve miles above Dúmagúdem, has been known for several years. It was noticed by Mr. Wall in his report of his journey to Kota near Sironchá in 1857, and the coal was by him supposed to be derived from the Tál river. An examination of the Tál for a considerable distance above its junction with the Godávarí, however, having proved fruitless, Colonel Haig, the Superintending Engineer of the Godávarí Navigation Works, asked me to examine the spot when I was marching down the valley in May 1867. I found that in the Tál, near its junction with the Godávarí, the only rocks exposed belonged to the Tálchír group, whilst the Damúdá shales and sandstones, which alone have been hitherto found in the Indian Peninsula to contain coal, appeared at the spot where the smaller stream joined the Godávarí, and I suggested that the coal probably came from a seam buried beneath the sand of the river, and advised exploration by digging away the sand and closely examining the rocks. This was done by Mr. Vanstavern, Executive Engineer, and resulted in the discovery of coal in four places, all a little lower down the river than the mouth of the Tál, so that the bed from which the fragments first found were derived has not yet been detected, but as a large quantity of silt and sand has been accumulated near the mouth of the Tál of late years, it is probably now covered to a considerable depth. The quality was inferior. Of the seams found, two, neither of them exceeding 2 feet in thickness, were detected close to the left bank of the river, opposite the village of Lingálá. The quality of the coal is rather inferior, and both seams thin out and disappear within a few yards; moreover, as the dip of the rocks at Lingálá is towards the river bed, or south-west, and the outcrop exactly parallel with the bank, it is clear that the beds, even if of good quality, could not be easily worked at this spot, as the whole of them within any reasonable depth must be beneath the bed of the river.

The third seam found crops out in the middle of the river bed; it is about 5 feet thick, and the quality appears better than in the other seams. The reef of sandstone resting on this coal can be fairly traced at intervals for some distance, and after running along the river for about a mile, it turns in towards the right or south-west bank. Here its course becomes obscure. Borings were put down by Mr. Vanstavern near the spot where the coal would probably crop out on the bank, but without success. Another thin seam, only 2 feet thick, has also been detected by Mr. Vanstavern on the right bank of the river. This, like the two first met with, thins out within a few yards in one direction.

I reached Dúmagúdem on the 25th December 1870, and learned from Colonel Haig that besides the coal at Lingálá near the mouth of the Tál, some had been reported farther down the river at a village named Madavàram below Bhadráchalam. This place is below the first barrier on the Godávarí, and is consequently at all times in free communication by water with the coast, whilst Lingálá is above the first barrier, and although communication is now possible during the greater part of the year, it is not easy for laden boats except for a few months. At the spot where coal was said to have been found, I could detect nothing except some shaly dark coloured sandstone, but the rocks around were unmistakeably Damúdás and there was every reason to hope for success in the search.

An examination of the ground showed that the Damúdá rocks extend for a short distance on both banks of the river, but that sections are very few and imperfect. On the left bank which belongs to the Upper Godávarí* districts, there are scarcely any rocks visible except at the hills near Daorpali, and these are probably of a higher group, nearly the whole surface elsewhere being covered with alluvium. The beds appear to extend about six miles along the river from Gogubáká to Nándigúr, but not more than from a mile to a mile and a half from the bank. On the right (south) bank of the river they extend about five miles from Palåram to the bend below Madaváram, stretching for a mile and a half to two miles inland. Above Paláram there is a break occupied by metamorphic rocks for a mile and a half; above this, again, at Pundigúl the Damúdás re-appear and occur for about one and a half miles to a little above Amraváram, then they are covered apparently by the Kámthís, but the two groups here resemble each other so much in mineral character that their limits are difficult to define, especially as nearly the whole surface of the country is thickly covered with alluvial deposit. The Damúdás near Amraváram cannot be traced more than about a mile and a half from the river's banks, beyond this limit they are entirely overlapped by the Kámthís.

Along the right (or south) bank of the Godávarí a tolerable section of the Damúdás is exposed, consisting of conglomerate, sandstone, shale and clay, but no coal. There are, however, many breaks in the section, and it is evident that an examination of these by boring would prove conclusively the presence or absence of any bed of coal extending over the whole field. Local beds, of course, might be found elsewhere, but their value must be comparatively small. It is also manifest that a thorough exploration can only be made south of the river, as to the north the beds are so much concealed that, except in a few spots, all borings must be put down at haphazard.

The general dip seen in the river's bank near Madaváram is to the westward, the rocks at the village being inclined at a high angle and much broken and disturbed; a short distance to the east down the river there is an anticlinal, at the spot where a small stream enters the river. From this point eastwards to the bend of the river, a distance of less than a quarter of a mile, the rocks either have a low dip to the east or are horizontal, and the prevalence of conglomerate shows them to be in all probability near the base or limit of the formation.

It is evident that the anticlinal exposes the lowest rocks to be seen on the river bank, and that a boring at this spot must penetrate beds lower in the series than any exposed elsewhere. On the arrival of the boring tools, I arranged with Mr. Vanstavern for a borehole to be begun at this spot. This was commenced on January 17th and carried on until April 12th, up to which time 192 feet had been penetrated; the borehole was then stopped in

* I do not know who bestowed this name on the districts, but it is an absurd misnomer. The Upper Godávarí can only be that portion of the river's course above its junction with the Pranhítá, if not higher still, where it traverses the Bombay Presidency. Sironchá at the upper extremity of these "Upper Godávarí districts" is 210 miles as the crow flies from the mouth of the river and 400 miles from its source!

consequence of the tools being required to prove the coal discovered on the opposite side of the river. The section passed through was—

		Ft.	In.
1.—Brown sandstone	... ...	24	6
2.—Shale and clay of various colours, mostly dark-grey	... ...	21	1
3.	Coal and shale mixed	0	6
	Dark-grey shale	0	7
	Ditto ditto with fragments of coal	0	8
	Ditto ditto	18	9
4.—White sandstone, conglomeratic in places, with thin beds of shale towards the base	... ...	53	9
5.—Shale and clay with a little sandstone	... ...	37	2
6.	Coal	0	8
	Black shale and coal	1	4
7.—Dark-grey shale with a few fragments of coal in two places	... ...	26	1
8.—White sandstone	... ...	8	4
		193	5

I next arranged for a series of fourteen borings to explore the portions of the section not exposed in the river banks to the west of Madaváram between that village and Damarcherla. These varied in depth from 6 to 200 feet, according to the extent of the breaks in the section, and the plan proposed was that all the smaller boreholes not exceeding 35 feet in depth, nine in number, should be made by jumpers with extra lengths of light rods to screw on. The remaining five boreholes alone would require the use of the heavier boring rods. In the ground opposite Madaváram no boreholes were put, because the breaks in the section are trifling, and the disturbance so great that there is reason to believe that a repetition of beds takes place.

To the west of Damarcherla one or two additional boreholes might have been required, but a little beyond the village the beds turn up, dipping east, and then roll over again, and just beyond the small anticlinal, very unpromising conglomerates, perhaps belonging to a higher group, come in, in which there is no break of section which could conceal a coal seam. Two or three small jumper holes were put down to the east of Madaváram.

Of the holes proposed six were carried out, *viz.*, four jumper holes and two boreholes, when peremptory orders were received from the Government of India to discontinue all boring operations in the Nizam's dominions. It is doubtful whether the boreholes in the bed of the river were in the Nizam's dominions, but pending a reference to the Government of the Central Provinces, one set of boring tools was moved across the river into British territory in order to test some ground near the boundary of the field, and close to the base of the measures, on a horizon which did not appear to have been proved by the borings on the opposite bank.

It should be stated that the borings, so far as they had been carried out on the right bank, had shown the existence of sandstones and shales similar in every respect to those seen in the bank of the river, except that in two or three instances small fragments of coal, proving the existence of very thin seams, probably not exceeding two or three inches in thickness, had been brought up by the borer. These little seams, although absolutely worthless in themselves, are of importance, as indicating that the mineral does occur in the beds, and that hopes may be entertained of larger seams being found.

The place selected for a boring on the north or British bank of the Godávarí was on the right or west bank of a stream called the Ganár, rather less than half a mile from the Godávarí, and about the same distance east of the village of Tátpali, at a spot where some brown sandstone, dipping to the south, is seen on the bank of the watercourse. A little more sandstone of the same kind is seen up the stream to the north, and then metamorphics crop out, the latter appearing about 500 yards north of the spot selected for boring. For

some distance east and west all is alluvium. It was hoped that a borehole at the spot selected would afford a section of the lowest Damúdá beds; lower than any passed through in the boring east of Madavâram. The borehole was commenced on the 12th April, and the section traversed was—

			Ft.	In.
(No. 1).		Soil and gravel ...	8	6
	*1.	—Brown and yellow sandstone ...	25	6
	2.	Shale, pale above, darker below ...	7	0
		Coal ...	3	0
		Do. mixed with shale ...	1	0
		Dark carbonaceous shale ...	5	0
		Coal ...	3	0
		Dark shale with 2 inches coal ...	6	0
	3.	—White sandstone ...	27	0
			86	0

The higher 3 feet of coal appears to be of better quality than the lower; an analysis of the small fragments washed from the samples brought up from the borehole gave the following (average of three samples from three different levels)—

Volatile ...	37·7
Carbon ...	42·7
Ash ...	19·6
	100·0

The volatile portion comprised 10·8 per cent. of water. This is by no means a good result, but still some use could be made of such coal, and it should be remembered that analyses of such samples as are obtained from borings are only approximations, although they are usually not far from the true composition.

When I heard of the discovery of coal I was about forty miles from the spot. I marched to it at once, but before I reached it, Mr. Heppel, who was carrying on the borings, had commenced a second borehole on some sandstone in the bed of the Ganár stream below No. 1 borehole at a distance from the first of 125 yards south-east by east. This (No. 2) gave the following remarkable section:—

			Ft.	In.
(No. 2).	1.	—Yellow and brown sandstone ...	28	0
	2.	Shale, partly dark-grey, partly buff ...	1	6
		Coal ...	2	0
		Shale ...	2	2
		Coal ...	0	6
		Shale ...	0	6
		Coal ...	1	4
		Shale ...	1	4
		Coal ...	1	0
		Shale ...	1	2
		Coal ...	1	8
		Shale ...	1	2
		Coal ...	1	
		Shale ...	0	10
		Coal ...	1	0
		Shale ...	2	8
		Coal (shaly) ...	1	9
		Shale ...	1	4
		Coal ...	0	8
		Black shale ...	5	0
	3.	—White sandstone ...	3	2
			60	8

* The numbers 1, 2, 3, before the several beds in the sections indicate those which are supposed to be representative of the same part of the series in each.

Altogether the combined bed of shale and coal measures 29 feet 6 inches, of which 11 feet 8 inches is coal, but the bands of coal and shale are intermixed in a way which would much increase the cost of working the seam. The astonishing change, however, in so short a distance as 125 yards from a bed 25 feet thick containing 7 feet of coal in two well defined seams exceeds anything usual even in India, amongst the very variable seams sometimes met with in the Barákár group, and this amount of change within so short a distance rendered it doubtful whether the seam could be traced to any distance.

It was now desirable, 1st, to ascertain the extent of the seam, and 2nd, its quality. For the extent two boreholes were put down, one to the east, the other to the west, at a distance of about one-third of a mile from No. 1, on the supposed strike of the coal seam. All the ground east and west for a considerable distance being completely covered by alluvium, the true strike could only be inferred from the line of outcrop of the metamorphic rocks to the northward. To the east the borehole (No. 4) was a complete failure. It was put down in an open plain north of the village of Ganára. It passed through 34 feet of earth and 18 feet of quicksand, in which no further progress could be made, as the sand filled the tube faster than it could be removed by the "pump" or mineral lifter. A second borehole 200 yards farther south (No. 5) was equally unsuccessful. After passing through 22 feet of soil and 24 feet of quicksand it also had to be abandoned. There was not time for more attempts in this direction.

The boring to the west (No. 3) was on higher ground, just south of the village of Tátpali. It gave—

			Ft.	In.
(No. 3).		Soil and gravel	3	7
	1 ?	Sandstone, yellow, brown, and red	29	9
	2 ?	Pale coloured shale	10	0
		Red and yellow sandstone with some shale	7	0
		Shale, pale and dark	13	0
	3 ?	White sandstone with a little shale and brown sandstone ...	24	8
			88	0

In my absence this borehole was stopped by Mr. Heppel, and another (No. 6) started 250 yards to the south-east. This was on somewhat lower ground, and as the beds dip south at a low angle the section is probably that of the same beds—

			Ft.	In.
(No. 6).		Soil	11	0
	1 ?	Brown sandstone	13	10
	2 ?	Buff shale	6	0
		Red sandstone	2	0
		Dark shale	6	0
	3 ?	White sandstone with darker bands	46	0
			84	10

These sections I am strongly inclined to believe are in the same beds as Nos. 1 and 2. We have the same general succession, brown and yellow sandstone above, then a thick bed of shale, and then white sandstone. I have recommended that one of the boreholes should be carried out to a greater depth on the possibility of these beds belonging to a higher horizon, but I cannot think this at all probable. The evidence afforded by these boreholes appears to indicate that the coal thins out and disappears to the westward within a short distance.

Meantime a locality for a small pit had been selected up the Ganár stream 350 yards north-east of No. 1 borehole, at a spot where some yellow sandstone, just like that immediately over the coal, crops out in the bank of the nala, in the expectation that this would be close to the

outcrop of the coal, and that a sinking of a few feet would produce abundance of coal to enable the quality to be fairly tested. A jumper hole, subsequently deepened by boring (No. 7), was put down in order to ascertain the presence of the coal. This gave—

			Ft.	In.
(No. 7).	1.	Yellow sandstone	29	6
	2.	Buff shale	24	0
		Dark shale	6	0
		Coal	1	3
		Dark shale	26	3
			87	0

showing that the beds are nearly flat, and that a great increase of thickness in the shale has been accompanied by a diminution in the coal. A pit was therefore commenced close to No. 2, but when it was only 13 feet deep, the quantity of water met with retarded progress so much that it was considered advisable to commence another on the high ground 30 yards west of No. 1, as, although it would be a little deeper, it would not be equally liable to flooding, and might be used for the extraction of coal. A borehole has shown that the section is the same as at No. 1. This pit is now in progress.

Meantime one more boring (No. 8) was made only 200 yards west-by-north from No. 1. The section was—

			Ft.	In.
(No. 8).		Soil and gravel	10	5
	1.	Coarse brown sandstone	4	0
	2.	Light coloured and buff shale	9	0
		Red sandstone	3	0
		Light blue shale	2	9
		Red sandy clay	14	3
		Variegated clay	13	0
		Dark shale	21	7
			78	0

This boring was in progress when I had to leave at the end of May, and I have not yet received accounts of its completion. The enormous thickness of shale recalls the section in No. 7, and both sections may possibly be below the white sandstone which underlies the coal. But it is more probable that the shale represents the shale and coal found in the two first boreholes.

Lastly, as the absence of coal had been proved to the north-east and west, and no borings had been found practicable to the east, while the ground to the south appeared equally unfavorable for boring, except at a place on the bed in the Godávarí where operations might at any moment, at the season now reached (June), have been stopped by a rise in the river, a borehole was recommended 500 yards south of No. 8 and south-south-west of No. 1. This (No. 9) has given the following section, sent to me by Mr. Vanstavern since my arrival in Calcutta—

			Ft.	In.
(No. 9).		Soil &c.	39	0
	1.	Brown sandstone and conglomerate	23	0
	2.	Dark shale	3	0
		Ironstone	2	6
		Shale	2	0
		Coal	1	6
		Shale	2	0
			73	0

		Ft.	In.
		73	0
2.	*Coal*	2	1
	Shale, carbonaceous	2	0
	Coal	1	6
	Shale, carbonaceous	1	6
	Coal	1	6
	Shale, carbonaceous	1	0
	Coal	1	0
	Shale, carbonaceous	2	0
	Coal	1	0
	Shale, carbonaceous	1	0
	Coal	2	0
	Shale	23	0
		112	7

The section is remarkably like that at No. 2. It decidedly strengthens the evidence in favor of all the boreholes having passed through the continuation of the same beds, for we have in this case a great thickness of shale as in Nos. 7 and 8, with the coal as in No. 2. The total thickness of coal as yet proved in this last borehole is 10 feet 7 inches.

To sum up the evidence: the presence of coal has been proved over a small area which contains probably 25,000 tons, or rather more, of which quantity it is as well not to assume that more than one-half can be profitably extracted, owing to the great admixture of shale. It is probable that the seam may be traced for some distance to the south, because the amount of coal, so far as is known, increases in that direction, but it is hardly likely that a seam which thins out and disappears within so short a distance as 200 yards can be depended upon for any long distance. The quality has not yet been accurately ascertained. If on cutting into the coal it is found to burn fairly, a considerable quantity may be extracted, far more than sufficient to well repay the expenditure incurred in boring, but, except in the improbable case of the coal continuing for a distance to the south and east, no permanent supply can be depended upon from this locality. The great admixture of shale and the variation in the seam will render it necessary to mine a large quantity of useless rock, and this will increase the cost of the coal, but in a country where no other supply exists, this alone should not prevent the coal being worked.

The locality is most favorable. The river is within half a mile when full, and about a mile during the dry season, and so soon as the coast canals are completed, it will be in constant water communication with Madras.

In conclusion, I would recommend that the remainder of this small tract of coal-bearing beds be thoroughly explored, as, even if no extensive seam of coal be found, a considerable quantity of useful fuel might be discovered, which would be available on an emergency. North of the river a borehole should be put down below the high bank at Rajgúmpa, at a spot where conglomerate is seen in the river bed, in order to test if the coal continues so far to the south-east. A boring might also be made where sandstone occurs in the stream north-east of Gaoriopeta, and another south of the large tank near Egerpeta, west of Tátpali, and one of the boreholes already sunk, for preference No. 1, should be continued until the metamorphics or Tálchírs are reached. There is little chance of good from any further exploration on the north bank. On the south or right side of the river, the series of borings planned west of Madavāram should be carried out. The small breaks in the section near Amravāram might be explored in the same manner, and especially a spot above the mouth of the large stream which enters the Godávarí just above the village, as small fragments of shale and coal are hereabouts scattered along the edge of the river, and may indicate a coal seam below the sandstone exposed at a place where there are some bushes beneath the bank.

If all endeavours to find a permanent coal supply in this locality fail, an eventuality for which we must be prepared, the next chance is near Lingálá. Here I consider further exploration in British territory as almost hopeless, the Tálchírs must crop out everywhere below the mouth of the Tál close to the river bank, so that the Damúdás are confined, or nearly so, to the bed of the river and the country on the opposite side. Above the mouth of the Tál for some distance it is simply impossible to say what exists, for the whole country is covered with thick alluvium as far as Cherla, where the only rocks that are known to occur appear to me undoubtedly Kámthís, and all the Damúdás and Tálchírs are overlapped. The only plan by which any good can be done is an exploration of all the breaks in the section exposed above the top of the Tálchírs at Sangáram on the right bank of the river in the same manner as I have recommended near Madaváram. The dip varies from 10° to about 20°, and the depth to which the boring in each case must be sunk will be found by multiplying the length of the break by the tangent of the angle of dip.

I am under great obligation to Mr. Vanstavern for the very thorough manner in which he has aided me, and for his readiness to carry out every suggestion I made. Mr. Heppel's services in charge of the boreholes were invaluable; it is mainly due to his thorough knowledge of boring and to his hard work, in an intensely hot season and despite many difficulties, that so much has been accomplished in a short time.

CALCUTTA,
July 6th, 1871.

NOTE ON THE NARBADÁ COAL-BASIN, *by* H. B. MEDLICOTT, A. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

From the point of view of uncertainty and of expectancy the Narbadá coal-fields are at present the most important in India. They are the nearest known source of coal for the great region of North-Western India, where so many miles of railway are either open, under construction, or projected. Even as communications now stand, with the circuit through Jabalpúr and Allahabad, these fields are much nearer than those of Bengal to the Panjáb. When the rails are laid through Malwa and Gwalior the length of carriage will be greatly reduced. Yet less is known regarding the resources of the Narbadá area than of almost any other. The Wardá fields have been comparatively recently brought to notice; but their value and extent have been so well established by systematic boring experiments that the working of them is now only a question of time and convenience. Until similar trials are made in the Narbadá fields the prospect of a supply of coal there must remain uncertain, the naturally exposed sections of the rocks being so very obscure. There is an immense area beneath which it is possible, or even probable, that coal exists; but its presence and the depth at which it must be sought are still unknown. In connection with this there is an interesting question of stratigraphy to be discussed, and which would be out of place in this brief notice of practical objects; the more so that I believe no amount of discussion upon surface observations could in this case finally settle the point or remove the necessity for actual exploration. The occurrence of a fine outcrop of coal in a convenient position at the northern edge of the basin, and the formation of an efficient mining establishment to work it, have, no doubt, contributed with other causes, such as the want of proper maps, to keep in temporary abeyance the further exploration of the field; but it is evident that this should no longer be deferred. My brief report of last year (Records, Geological Survey, Vol. III, Pt. 3,) showed how much need there was for information regarding even the seams on the Sitárivá (at Mohpáni); how limited their known extension; how broken, crushed, and even locally destroyed they are within those small limits; how urgent it was

Lithographed in Colors at the Surveyor General's Office. Calcutta. July 1871.

to ascertain their extension beneath the younger rocks to the south. Although little information has been gained within the last twelve months, and that little not very encouraging, the importance of the case makes it worth noting. The following notes, in continuation of my last year's report, refer only to the northern side of the coal region: every endeavour should be made to find the coal there before attempting to work the distant outcrops of the Upper Tawa valley, on the south side of the basin. The localities to be mentioned in this paper may be followed upon the small map attached to the report of last year, or upon the large sketch map of 1859.

During part of the past season I examined a number of sections along the northern side of the area of sedimentary rocks from end to end. but without discovering an outcrop of the coal-measure rocks (the Barákar group). This direct evidence failing, the fact that has most encouraged hope of the proximity of coal has been the occurrence in several places of Tálchír rocks, which so constantly underlie the coal-measures. The outcrop in the glen south of Futtehpúr was mentioned in last year's report. A much larger spread of the same rock is seen at the edge of the plains south of Dhábká, eight miles east-south-east of Sohágpúr: again, to east of the Sitárivá, half way between Chungaon and Hatnápúr, close on the west of Nibhora village. But even this evidence is open to doubt: in all cases the rock in question is indeed the lowest seen, and is identical with the well known Tálchír boulder clay; but except for the boulders (which are not of large size) an identical clay is common in the adjoining Máhádévá rocks, alternating with the more common mottled red clays. Thus, the identification of this boulder bed as Tálchír rests largely on the assumption that there is no such bed in the Máhádévás; it is certainly very different from the ordinary conglomerates of this series. It is moreover noteworthy that in the undoubted Tálchírs of the Sitárivá section *sandy* rocks prevail: even the boulder-bed is principally a sandstone, the clay being subordinate. I am, however, decidedly of opinion that the rock in the localities noticed belongs to the Tálchírs. The presumption thus gained in favor of the proximity of the coal-measures along this edge of the field is, no doubt, an uncertain one; but it is something; the Barákur and Tálchír groups being about the two most constant companions of all the groups of the great plant-bearing series. It will probably be advisable at some early date to make one or more deep borings through the Máhádévá rocks at some little distance from the edge of the basin; but, as was urged last year, it would be unwise to attempt this until it be seen what can be learned from the exploration of the Sitárivá field as to the conditions of the formations in passing southwards.

Very little has been added during the past year to our knowledge of the seams in the Sitárivá (Mohpáni) field. What explorations have been made only bring into clearer view the greatly disturbed condition of rocks within the area exposed, and the corresponding deterioration of the coal. In the pits on the vertical seams at the north edge of the field the coal has become greatly squeezed-out at a depth of 100 feet, and along the strike westwards, being at the same time reduced to an useless paste. Some shallow excavations on the outcrops in the ravine to the north of the Narbadá Company's mine show the coal to be tremendously crushed and mixed with the associated rock; two strong trap-dykes here passing within a hundred yards of each other right through the measures. The trial boring at Pukuhi was carried to a depth of 110 feet. The result was inconclusive and, in a measure, unexpected. The sandstone, which from its position and general appearance it was thought might be the top-rock of the coal-measures, proved to be only a band in the Máhádévás; the bore having gone through some 60 feet of the typical red clay beneath it. Below this, however, the bore passed through dark-brown and dark-grey, slightly carbonaceous, clay. Such a rock would be very unusual in the Máhádévás in this position; and would, on the contrary, fairly represent the top of the coal-measures in the

northern section on the Sitárivá; the two being, moreover, on the same general strike. Regarding the southern extension of the seams, where, it may be hoped, they become steadier and farther from trap, no result has as yet been attained. The small trial-shaft and boring close to Benár on the north-west not having proved coal within 50 feet, Mr. Taylor shifted his operations to a point south-east of the village, and well in on the Máhádévá rocks where he is now boldly sinking a shaft. He could not, within his limits, have chosen a better position for making a thorough trial of the ground. According to the nearest dip seen (25°), and supposing no intervening fault, the shaft may have to be sunk 235 feet before striking the measures; but there is hope that the dip flattens, so as to lessen the depth. The shaft is now 98 feet deep, 92 feet of which were through an unbroken mass of mottled red clay, locally silicified and very hard, but all requiring to be cased up. The bottom 6 feet are in a firm, clear gray, sandstone-conglomerate. The plane of junction, which (Mr. Taylor informs me) seemed regular, thus affording a fair observation of the dip, sloped at 18° to the south-south-east. The prospects are so far improving. The spirited enterprize of Mr. Jones, the present proprietor, deserves every success.

In my small map of last year I marked some Tálchír rocks, with a query, on the south of Puwaria village. A re-examination of that obscure section, later in the season, when the ground is less concealed, has convinced me that the rocks are Máhádévá; thus making the suppression of the older rocks to the westward of the Sitárivá much more rapid than was at first apparent. But there is no deciding as to the manner of this suppression; it may be altogether due to faulting or to folding of the strata. The alternative supposition to that of disturbance to account for this so sudden disappearance of the coal-measures would be that there is strong denudation-unconformity between the two rock-series. There are some puzzling sections about the mines seeming to corroborate this view of the case; still it is hard to get over the fact first adduced against it—that in the best exposed sections the succession of the rocks seems regular. And there certainly can be no objection now to the supposition of disturbance. The unpromising nature of the ground in this position, at the edge of the basin, is further displayed in this section at Puwaria by the discovery of four strong trap-dykes, or at least outcrops (the section is so flat one cannot positively say how the trap occurs), in a length of about three quarters of a mile.

Several new outcrops of the lignite-coal in the Upper Máhádévá rocks have been examined during the past field season in the hills east of the Sitárivá. They all bear out the opinion already given on the subject.

There remains to notice the coal near Lokartálai at the extreme west end of the basin, so far as exposed at the surface; the whole sedimentary series there passing beneath the trap. The coal-band here seems different to any yet noticed. It occurs (see small map annexed) at some distance from the boundary of the metamorphic rocks, being exposed in a trench cut by the Moran across a flat anticlinal fold of the strata. The upper rock is a strong pebbly Máhádévá sandstone, but on what exact horizon has not been determined, immediately beneath which come the earthy coal-bearing beds. There is the usual appearance of complete conformity; the upper rocks dipping at the same angles as the lower; and the same beds of shale being identifiable on both sides of the anticlinal; a thick bed of nodular and shaly, micaceous and carbonaceous clay is recognizable at a few feet below the sandstone on either side. There are altogether about 80 feet of the lower rocks: 40 to 50 feet at top are earthy, some of the layers of shale containing strings of bright coal. These are best exposed in the southerly elbow formed by the river. They rest upon a thick mass of fine sandstones, between which and a similar mass below occurs the principal seam. It is about 4 feet thick. What coal there is in it is very bright; but shale predominates in the mass, and there is a great deal of pyrites. Some explorer had last year cut a short drift into the seam and evidently abandoned it as worthless. This seam is about the lowest

bed exposed on the back of the anticlinal. I do not think that this band of coal-bearing rocks belongs to the Barákar group. I rather think it belongs to those younger beds of the Damúdá series so largely exposed along the south base of the Pachmari range, and in which as yet no coal-outcrops of any promise have been found. Or, it may possibly belong to the Máhádévá series. I was not fortunate enough to find any fossils to determine this point; and owing to the isolated position it will be a very tedious matter, if even possible, to work out the question stratigraphically.

CAMP,
May 1871.

SKETCH OF THE GEOLOGY OF THE CENTRAL PROVINCES, *by* T. OLDHAM, F. R. S., *Supdt., Geological Survey of India.*

[In connection with the valuable series of Gazetteers which are now in course of publication under the authority of Government, the Geological Survey have from time to time afforded information to the officers charged with their compilation. This has frequently been on isolated points, but we have also been urged to give general and sketchy outlines of the geology of the various provinces viewed more as a whole. Such sketches are necessarily brief, being very limited in the space intended for them, but they may be useful to others as giving a more general outline than separate reports could do. It is, therefore, in contemplation to reprint these in the present series of records. Of those which have been already furnished, that of the Central Provinces has appeared soonest. It is now given here. It was written entirely without a single map or record for reference, and very hurriedly under great pressure for time. Others of Orissa, North-Western Provinces, Bombay, &c., will follow.] T. O.

Diversity of the geological character of the country.

To give a general description of the geological structure of the Central Provinces in any detail would involve the necessity of entering upon a discussion of the geology of India at large, as these provinces contain representatives of almost all the formations known to occur within Indian limits, although frequently these are much better seen in other districts, and ought, therefore, more correctly to be described in connection with the locality where the most typical sections occur. In the very brief notice which follows I am therefore compelled to presuppose a certain amount of acquaintance with Indian rocks, and the classification of them. It is only necessary to state that the few descriptions which follow have been drawn up under great pressure as to time, and while actively engaged in field work of an important and intricate nature, and away from all maps and records.

General correspondence of geological and physical areas.

The Central Provinces, divided into nineteen districts, naturally group themselves into separate areas, corresponding to well-marked physical features. These again have in a similar way a general agreement with the geological structure. To the north the districts of Ságar and Damoh are altogether on the Vindhyan plateau, and a large part of their surface is formed of the deposits to which the name *Vindhyan* has been given. These are, however, concealed over considerable areas by the overflowing volcanic rocks of the great Deccan trap area. Physically also these districts (as is all the Vindhyan plateau) are connected with the country to the north, all the drainage of the area being into the Ganges valley. Immediately to the south of the Vindhyan escarpment, along the marked depression of the Narbadá valley, lie the four districts of Jabalpúr, Narsinghpúr, Hoshangábád, and

Nimár (taking them in order from east to west), which are in great part on alluvial and tertiary deposits, with a narrow belt of older rocks along the southern side of the valley. South of the Narbadá valley rise the extensive highlands constituting the Sátpurá range, or its continuation, which are in great part formed of the Deccan traps resting upon crystalline rocks, or upon sandstone and other rocks of later date. Of this region Mandla occupies the extreme eastern end, bounded by the steep escarpment of the trappean plateau, near to the edge of which the Narbadá river has its source at Amarkantak. Along this same range to the west lie parts of Bálághát, Seoní, Chhindwárá, and Betúl. South and south-east of the Sátpurá ranges lie the remaining districts. Biláspúr, Ráípúr, and Sambalpúr lie in the great drainage basin of the Mahánadí. The two former occupy the low plain country of Chhattísgarh, formed principally on rocks believed to belong to the *Vindhyan* series, with a part of their area covered by coal-bearing rocks. Sambalpúr is in a rugged jungly country composed of crystalline and metamorphic rocks. The great drainage basin of the Godávarí, on the other hand, includes Nágpúr, Bhandára, Wardhá, Chándá and Sironchá. These districts have no very considerable elevation. The two first are principally on gneissose rocks, with much trap in Nágpúr: Wardhá is almost entirely on trap-rocks; Chándá and Sironchá have a very varied structure, including more or less of all the formations that have been named.

Geological groups.
Crystalline and metamorphic rocks.

These formations may be noticed in ascending order. The crystalline and metamorphic rocks have not as yet been described in any great detail. Gneiss of different varieties, often highly granitoid, predominates. The frequency with which these rocks appear shows how closely to the surface they form the substratum of the whole area. They are found at intervals all round the irregular boundary or border of the trappean rocks, rising in several places nearly to the full height of the plateau. The principal areas occupied by them are in Nágpúr and Bhandára and in Betúl. Also in Sambalpúr a very large area is formed of these rocks; but this is naturally connected with, and belongs to the great Gneissic area of Bengal. In obscure relation to the gneiss there occasionally appear sub-metamorphic rocks, schists, slates, and quartzites. These may be seen at many points along the borders of the Narbadá valley, from the north-east of Jabalpúr into Nimár.

Sub-metamorphic rocks.

Vindhyan series.

The great *Vindhyan* series of strata which form so prominent and important a feature in the geology of Hindustán are the next deposits in succession of age found in the Central Provinces. There is, however, a wide and complete separation of these from the gneissose rocks. They are universally unconformable to the latter, and they exhibit little or no mineral alteration, and only very locally any marked mechanical disturbance. The range or escarpment, from which the name of the series has been adopted, forms the northern boundary of the Narbadá valley, and the districts of Ságar and Damoh are occupied by the upper member of the series—the *Bhánrer* and *Rewá* groups. Each of these groups consists of a strong band of sandstone resting upon shales with subordinate limestone—an arrangement which, coupled with the nearly horizontal position of the beds, has, through the operation of denudation, produced the peculiar surface features of the country, namely, local plateaus bounded by precipitous scarps, overlooking broadly undulating valley-plains—features even better seen in the Rewá country. The Bijerághogarh *pargana* in the north-east corner of the Jabalpúr district lies within the geological region of the Son valley, where the *Lower Vindhyan* rocks are so well exposed: they consist of less uniform alternations of shales, sandstones, and banded limestones, with some peculiar compact silicious (cherty and jaspery) layers, very homogeneous and regularly bedded. Along the entire southern margin of the *Vindhyan*

area these rocks both '*Upper*' and '*Lower*' are much crushed and contorted, but they are only locally (in the south-west) penetrated by igneous rocks, probably of the same period as those of the great basaltic area. The extensive plains of Biláspúr and Ráípúr are formed on rocks very similar in composition, arrangement, and external relations to those of the *Lower Vindhyan* formation as seen to the north, and these extend from here along the upper courses of the Mahánadí into very close proximity, if not actual continuity, with the similar deposits in the Chándá and Sironchá districts, and beyond the limits of the Central Provinces to the south, extend at intervals into the Madras Presidency, where they cover an immense area in the Kaddapá and Karnúl districts. Our knowledge of these detached areas is not as yet sufficient to justify an assertion that they were once continuous, although the striking identity in lithological character of the several deposits lends strong support to this view. Throughout all these widely-extended deposits there is constant physical evidence of their having been accumulated in comparatively shallow water, and so far under physical conditions favourable to life. The sandstones are false-bedded and beautifully rippled on their surfaces, each successive bed, often for hundreds of feet in thickness, showing its own ripple-marked surface. Nor is there anything in their mineralised condition to suggest the chance of subsequent obliteration of organic remains, had they ever been imbedded or become fossilised. Yet no success has hitherto rewarded our most careful searchings for such traces of early existences.

Coal-bearing rocks.

Passing upwards in the historical succession of rocks, we find in India a wide gap in the geological record between the *Vindhyan* rocks, just alluded to and the next succeeding series of deposits, in which are included the coal-bearing rocks. The whole face of the country wherever these occur must have been entirely remodelled by long-continued denudation and other causes before the commencement of the deposit of this great plant-bearing series of beds. This series has attracted much attention, both from its economic importance, and from the fact that it is in all its groups more or less fossiliferous. And the proper sub-division of it as represented at distant localities has been the subject of much study. Nor has the detailed examination of the country yet been sufficiently extended to admit of a final decision of this question.

Sub-divisions.

Three great groups have, however, been thoroughly established—the *Tálchír*, the *Damúdá*, and the *Panchet* rocks, and representatives of these three great groups have been found wherever the general series occurs. It is solely as to the exact limits of each that any question still exists, which can only be answered after more detailed examination. This question is, however, of high practical importance, because of the three series which I have mentioned only one is proved to contain workable beds of coal. The *Tálchír* rocks below contain no coal, and the *Panchet* rocks above are equally without any coals, the whole of the workable beds of coal of this geological epoch being found confined to the *Damúdá* rocks.

Sátpurá coal-fields.

The largest area occupied by the rocks of this great series within the Central Provinces lies in the hilly region to the south of Hoshangábád and Narsinghpúr, partly within the boundaries of these districts, but principally belonging to Chhindwárá, and embracing the Pachmarhí or Mahádeo hills. At the base of the series we find the characteristic deposits of the *Tálchír* group—greenish silt beds, breaking up into small splintery flakes and sharp fragments, and hence called 'needle shales,' and greenish brown or whitish earthy felspathic sandstones, in either of which pebbles and large boulders are often irregularly scattered. Often these are very numerous and form a distinct bed, to which, from its peculiar constitution, the name of "Boulder" Bed has been given. These rocks, generally speaking, are

found at the edges of the field, or weathered out in the deep valleys. The thickness of this group is variable, never very great, and it is locally altogether overlapped. In the Narbadá it covers by far the larger portion of the area. As noticed, no coal has ever been found in the *Tálchír* rocks, and very rarely any of the dark carbonaceous shales which are so frequent an accompaniment of coal, with the exception of a few thin and irregular streaks which invariably mark the transition of these *Tálchír* rocks into the *Damúdá (Barákar)* rocks above. This *Damúdá* series is chiefly made up of thick-bedded, often coarse felspathic sandstones, with subordinate beds of blue and carbonaceous shales and *coal*. In Bengal and towards the east this series is of great thickness, and is easily divisible into several distinct groups. But towards the west and the Central Provinces the series is of much diminished thickness, and the sub-divisions so well marked in Bengal are not recognisable. The beds of coal in the same way are much fewer and less important. These variations appear to have only a local development when viewed in detail, while on a general comparison the facts would seem to be expressed by saying that the *Panchet* series, which immediately succeeds the coal rocks, assumes towards the west a much greater thickness and importance than in the east, while the *Damúdá* series has been much less developed. In the Narbadá valley the latter series is represented by one group of beds only, which belong to the lowermost group recognised in Bengal (the *Barákar*), of no great thickness, and covered by an immense series of sandstones of varying age. No trace of any one of the sub-divisions of this great plant-bearing series—*Tálchír*, *Damúdá*, or *Panchets*—has been found to the west of about the parallel of Hoshangábád (Lokhartalai). The *Damúdá* rocks cover a wide spread of country round the bases of the noble Pachmarhí hills, and extend thence to Umréth and Barkoí, about sixteen miles from Chhindwárá. They rest in parts immediately on the gneissose rocks, and are frequently succeeded directly by the great trappean flows.

Western limit.

In Biláspúr (Chattísgarh) a large area of widely undulating country along the Hasdú—an affluent of the Mahánadí—is also formed of these rocks, and coal has long been known to exist there in some quantity. The district has not been examined as yet, and no trustworthy information exists as to the quantity or quality of this coal.*

Biláspúr coal-fields.

In the Chánda district again, and in Berár adjoining, similar *Barákar* rocks are found resting upon the characteristic *Tálchír* beds, and occupying a very small area in the large field of sandstones which there occur. At least one thick group of beds with coal is known in which the coal itself exhibits the same characters which distinguish the beds in the *Barákar* series elsewhere—that is, there is rapid and considerable variation in the thickness and quantity of the coal. Beds of great thickness have, however, been met with, and there is a very large supply therefore of useful fuel.

Wardhá River coal-fields.

Similar rocks extend down the valley of the Godávarí and the Pranhítá for a long distance, occurring in detached localities separated by wide ridges of the older formations. Near the mouth of the Tál river about fourteen miles above Dúmagúdem, both *Tálchír* and *Damúdá* rocks occur, the latter containing coal, which form the bed of the river Godávarí for some distance, and have probably a considerable extension; and coal is also known to occur about thirty-four miles to the south of the same town, visible on the banks of the river.

Godávarí and Pranhítá.

* See later information in Records Geological Survey of India, 1870, p. 71, also p. 54.

We are not as yet able to speak so certainly of the limits and relations of the beds which occur immediately above these coal-bearing rocks, so far at least as parts of the country under notice are concerned. In the Narbadá valley coarse conglomeratic sandstones with ferruginous bands, which are believed to be the representatives of the *Panchet* rocks of Bengal, come in immediate succession on the *Barákar* beds (Mohpání, &c.). And similar rocks occur in the same relation in the wide flats of Chhattísgarh, and probably at the intermediate locality of the Chhindwárá fields.

Kámthí sub-group.

But passing into the drainage basin of the Godávarí, a series of rocks of peculiar lithological character and locally abounding in fossil plants, is met with, no exact representatives of which are as yet known elsewhere. In their general mineral aspects they come very near to the ordinary *Panchet* rocks of Bengal, and they appear to pass upwards into undoubted representatives of these, but the prevailing form of fern of which they contain the fossilised fronds, is one *(Glossopteris browniana)* which is scarcely known to extend up to the *Panchet* horizon. These beds would therefore seem to indicate either a commencement in the basin of the Godávarí of the deposition of rocks having the peculiar mineral character of the *Panchet* beds at a much earlier period than in Bengal into which these ferns continued to exist: or the flora of the Godávarí basin had not been subjected to the same influencing causes, resulting in a marked change in its character, which in Bengal led to the well-defined separation as to fossils of the *Panchet* and upper groups of the *Damúdá* rocks *(Raníganj)*. I am disposed to think that, viewed in a very general way, it gives the truer representation of the facts to consider these local rocks, notwithstanding their contained plants, as belonging rather to the *Panchet* series than to the *Damúdá*. And there is one very important practical reason for this also, inasmuch as no workable coal has yet been found in either of these groups, while it has invariably been seen to occur where rocks of the undoubted *Damúdá* age are developed.

A local name was provisionally given to these rocks by Mr. W. Blanford, who first examined them, and as this has been published (although unintentionally), it may be retained as a useful sub-division. One of the largest areas of these rocks in the Nágpúr country is close to the important military station of Kámthí, and from this circumstance Mr. Blanford spoke of them as the *Kámthí* beds. They consist, lithologically, of hard compact gritty sandstones, fine variegated sandstones, coarse loose-textured sandstone, very fine-grained deep and bright red and buff argillaceous or argillaceo-silicious sandstones, and bands of hard very ferruginous pebbly grits.

These rocks cover an area of about twenty-five miles long from north-west to south-east near Kámthí (Kámthí to Kélod), and at the broadest parts (near Pátansáongí) about eight miles wide. Over a large portion of this area the rocks are concealed by thick alluvial deposits, but they are well seen at Kámthí, Silewárá, Bhokárá, and south and south-east of Pátansáongí, &c. A small area of the much older *Tálchír* rocks is seen north-east of Bhokárá, and a small hill north-east of Pátansáongí. Two other localities where these rocks are seen have been exposed within the area of the trap-rocks, these having been removed by denudation. One—the larger of the two—is close to Behár and Bázárgáon, about fifteen miles from Nágpúr on the road to Amráotí. The rocks here are of the same type, but become more conglomeratic towards the top than is seen near Nágpúr. The other inlier of these rocks is about thirty-six miles north-west of Nágpúr, near the village of Chorkherí. The rocks extend over an area of only about six and a half square miles in all. There, is also another very small patch not a mile long near Khútkherí, about one mile south-east of the other.

Passing further southward similar rocks are more widely developed in the Chándá district, and cover a large area, concealing the underlying *Barákar* beds; there the rocks are, as a whole, less fine-grained than in the neighbourhood of Nágpúr, and the tendency to become more conglomeratic in the upper beds of the group is still more markedly exhibited than in the case already noticed. In this field also they appear to be closely connected with, and to pass up into a great thickness of bright red clays with thin-bedded sandstones, which belong undoubtedly to the *Panchet* series—well seen in the Wardhá about Porsá and in the country round, giving additional evidence of the connection of the two groups. These rocks—the *Kámthí* beds—yield in many of their beds admirable building stones, while others of a coarser texture are used as millstones or querns. Quarries exist at Kámthí, Silewárá, Bhokárá, &c., also in the Chándá district, but owing to the comparative poverty and sparseness of the population, they are here less worked than in the Nágpúr country. The white argillaceous band which is used near Chándá town, and which can be traced for miles along the country, is very even in texture, and can be carved into very minute forms of ornaments (a kind of work which is very skilfully done at Chándá), but it is rather soft. The beds, excepting the hard ferruginous pebbly grits, are not, generally speaking, very compact, and the surface of the ground becomes covered with loose sand resulting from their disintegration. The soil on these, except where they are covered by the alluvial deposits, is poor and little cultivated, almost the whole of this tract being covered with jungle.

The fossils found in these *Kámthí* beds have been noticed above. The fine sandstones of Kámthí, Silewárá, &c., have yielded very beautiful and numerous specimens of the large *Glossopteris Browniana*—a fossil-fern common in the coal-bearing rocks of Bengal and also in those of Australia. Similar fronds are found, but more rarely, in the finer beds of the vicinity of Chándá.

We have noticed these so-called *Kámthí* beds a little more in detail than their relative importance in a general sketch would justify, because of their local development, and of the interesting fossils which they contain.

Panchet series.

In ascending order the next important series of rocks is that to which the name of *Panchet* has been given. This, which is a very extensive formation in Bengal and in the country intervening between that and Jabalpúr, is not so largely developed in the Central Provinces. Indeed there is still much doubt as to the true limits and true parallel of many of the rocks which would probably at first be classed under this group. There is another peculiar feature: in the Bengal coal-fields, the so-called *Lower Panchet* group, consisting principally of red clays, with fine-grained, thin-bedded, often calcareous sandstones, both of red and greenish white colours, forms a set of beds of very considerable thickness and wide extent. But on passing to the west this group rapidly disappears and soon seems to be entirely wanting, while the *Upper Panchet* group, consisting chiefly of coarse red conglomerates, &c., with numerous ferruginous bands, becomes more largely developed, and constitutes almost the whole of the series. Still further to the west, however, as in the Chhindwárá fields near Umréth, these red-clays and thin-bedded fine-grained sandstones recur with a considerable development. And similar beds cover a large area on the south of the Chándá coal-field (Porsá and all the country around), and also appear in other minor patches throughout the Chándá field and in Berár. These pass upwards into coarser beds, pebbly and conglomeratic, and it is not an easy task to make out the exact relation of these to the adjoining rocks in a country so very much covered as is the greater part of the Chándá district. Similar rocks are seen again further south (Maledi), and here, as at Manglí to the north of Chándá, have yielded organic remains, which establish with tolerable accuracy their true position in the general European scale of geological formations.

Several forms of *Labyrinthodont* reptiles from the *Lower Panchet* rocks of Bengal remains of the very remarkable genus *Dicynodon,* previously only known from South Africa, and abundance of *Estheriæ* (small bivalved crustaceans) mark the fauna of the time in Eastern India. In the Central Provinces similar *Estheriæ* and a remarkable reptile *(Brachyops laticeps)* have been obtained from Manglí thirty miles north of Chándá, while the red clays of Maledi afford numerous remains of the very curious and interesting *Hyperodapedon, Belodon,* and some *Labyrinthodont* fragments also. There is a high probability that the rocks at these different localities are all truly on or about the same geological horizon (a fact which can only be satisfactorily established by detailed and careful observation), and that that horizon represents in Indian geological homotaxis the period of the *Trias* of Europe.

Jabalpúr beds.

In the vicinity of Jabalpúr and stretching down the valley of the Narbadá to the Sher river, and a little beyond, and forming also a narrow outcrop fringing the general line of the trappean boundary to the east and north of Jabalpúr, a distinct group of rocks was recognised by Mr. J. G. Medlicott in 1856-57. This limited group of beds is partially coal-bearing, and from this fact and from certain other obscure relations, it was at first designated under the inappropriate name of *Upper Damúdá,* with which series it was, pending further inquiry, supposed to be connected, while the fossil plants which it imbedded were closely allied to those occurring in the *Jurassic* beds of Rájmahál and Cutch. Subsequent inquiry showed that there was really no ground for supposing any connection of these beds with the true *Damúdá* as parts of one formation, and the name *Jabalpúr* group was substituted for *Upper Damúdá.*

At about 100 miles to the north-east of the Narbadá coal basin the boundary of the plateau of trap-rocks recedes south-eastwards, and the narrow outcrop of these *Jabalpúr* beds expands here into the open ground of South Rewá; there the *Jabalpúr* shales and silt beds were found passing upwards into massive sandstones (at Bandogarh) so generally identical with the rocks of the great Mahádeo hills, that they were at once accepted as their representatives; while below the *Jabalpúr* shales overlaid strong pebbly sandstones and conglomerates, which again in the southern part of the same area rested upon a coal-bearing group, recognisable at once by its contained fossils and general character as representatives of the *Damúdá* series. The *Jabalpúr* beds have not as yet been traced with any care in other districts, and I am unable to state their true limits. Their contained fossils point distinctly to a *Jurassic* age and to the lower part of that great period. In the Narbadá nothing but plant-remains have been found. We may, however, although the connection has not been traced, point to the remarkable beds near Kota—about five miles from Sironchá—which have yielded several well-marked fish-remains *(Lepidotus Deccanensis, Æchmodus, &c.)* considered as *Liassic* in their relations, as a probable representative to the south of the *Jabalpúr* beds to the north. There are also some detached patches of rock which occur in the intermediate country which may be representatives of the same general age. The coal found in these *Jabalpúr* beds is very irregularly developed (Sher river; Lametá-ghát). It is jetty, and has much of the character of a true lignite; indeed in many specimens the structure of the now-carbonised stems, of which a large portion of it is made, is well preserved. It has been economised recently to a considerable extent by the contractors on the Great Indian Peninsula Railway. But neither in amount nor in quality does it constitute a source of fossil fuel of any importance in a general view. I mentioned above, that immediately resting on the *Jabalpúr* beds, where the succession is best seen *(South Rewá),* came the massive sandstones of Bandogarh, which were accepted as representatives of the great *Mahádeo* group, so well seen in the upper and magnificent scarps of the Pachmarhí hills (Central Provinces).

Mahádeo beds.

This *Mahádeo* group was first established after a brief examination of these hills in 1856-57, and was shown to contain a vast thickness of massive sandstones, with many ferruginous bands which *appeared* to be entirely unconformable on the *Damúdá* beds forming the lower ground adjoining. Unfortunately the same name was applied to rocks in other places which showed an approximation to the same general character, and which appeared to stand in the same general relation of an entirely unconformable series above the *Damúdá* rocks. It was from the first indicated that these *Mahádeo* rocks would require further examination. The progress of geological investigation in India has since shown the necessity also of greater sub-division than was at first apparent. These *Mahádeo* rocks, with the exception of a few badly-preserved and generally large stems, are, so far as known, unfossiliferous, and have therefore not attracted quite as much attention as some of the other series I have noticed. This absence of fossils also, and the detached, or comparatively detached, positions in which the *Mahádeo* rocks occur, have rendered the question of their geological age more difficult than it would have otherwise been.* Mr. W. Blanford, carrying up his examination of the country from the west, gave some good reasons for supposing that the *Mahádeo* beds were the continuation and expansion of the cretaceous sandstones found near Bágh in the western Narbadá. A similar general conclusion had been suggested by Mr. Hislop previously, but without much proof. On the other hand, it is right to state that Mr. Medlicott, working up from the east, saw reason for supposing that the *Mahádeo* beds in the Narbadá districts, which he presumed to be truly representative of the Bandogarh rocks in South Rewá (and as a subordinate member of which he considered the *Jabalpúr* beds), were at the same time only an upward extension of the same uninterrupted succession of deposits, which elsewhere had been justly believed to belong to the *Panchet* series.

It will be seen from this that the true position of these beds has not as yet been fixed. When first examined it was by me supposed that they, including the *Lametá* group (to which we shall presently refer), represented the lowest portion of the tertiary period. The Rev. Mr. Hislop, whose untiring exertions have done so much to elucidate the palæontological history of the Central Provinces, was disposed to view them as below all the tertiary deposits, and as representing in India the upper portion of the *cretaceous* epoch of Europe—a view strongly confirmed by Mr. Blanford, who was disposed to put them only a little lower in the series, while Mr. Medlicott would now make them much more ancient, and would place them in the same sub-division as the *Jabalpúr* beds, which latter are probably on the horizon of the Kotá beds—that is, he would consider them *Lower Jurassic.*† As stated, the question cannot at present (January 1870) be definitely settled.

Lametá beds.

When first examining the Narbadá valley Mr. J. G. Medlicott distinguished in the country fringing the river to the south, and between the Mahádeo hills and Jabalpúr, a series of well-marked beds, which he was then disposed to consider as the uppermost group of the *Mahádeo* formation, and to which he applied the local name of Lametá. These *Lametá* beds consisted chiefly of whitish earthy and silicious (cherty) limestones or calcareous muds, often a good deal indurated. These sandy calcareous beds formed only a thin band immediately underlying the trappean rocks. Further and subsequent examination, extending more to the east, proved that this band was entirely independent of the rocks below it, with

* The statement originally made that a very perfect specimen of a true *Archegosaurus* found under the Pachmarhí hills had been obtained from these rocks, was at once refuted by the mineral character of the rock in which it was imbedded. It was from the *Damúdá* beds below.

† The Rájmahál group of Bengal would in this view be of course younger than the Máhádévá of the Central Provinces.

which it was associated, inasmuch as, following the trappean boundary to the south-eastwards, the *Lametá* group was found to accompany the trap-rock steadily and to rest indiscriminately upon all rocks, from the gneiss up. It was therefore clear that it must be viewed as entirely separate from the great *Mahádeo* series, and as intimately connected with the overlying trappean rocks. As noticed above, these *Lametá* beds consist chiefly of cherty and gritty limestones, with subordinate beds of a nodular limestone, loose greenish sandstone, and purplish or greenish argillaceous beds either sandy or marly. They have been traced considerably south of Nágpúr, and thence at intervals round by the trappean boundary to Jabalpúr, and down the Narbadá valley to near Hoshangábád. If Mr. Blanford's views be supported by further examination, the limit must be carried very considerably to the west to the Punásá and the Dhár forest. In all cases, too, the trap-rocks, where any section is seen, appear to rest quite conformably or continuously on these *Lametá* beds, and beds which cannot be distinguished from them mineralogically are frequently met with interstratified with the traps (as near Nágpúr and between Nágpúr and Jabalpúr).

Intertrappean series.

These remarkable sedimentary beds intercalated with the traps of the Deccan and Málwá areas have received much attention. They constitute the *Intertrappean series* of Hislop, and are interesting from their fossil contents, as well as their mineral character and peculiar stratigraphical position. It would be out of place here to enter into any discussion of the various explanations which have been given of these. It must suffice to say that both in their lithological character [calcareous muds]; in their distribution [local and irregular lenticular masses, not extending laterally to any great distance]; in the fossils contained [fresh-water and lacustrine shells, fragments of plants, &c.], and in their occurrence invariably between the successive flows of trappean rock, the upper surface in all cases being the only one really indurated or altered by the contact of the igneous, heated mass, they indubitably point to their origin in the small and irregular deposits in lakes or pools of varying size, tranquilly thrown down during the intervals of the successive flows of the lava, which now forms the great covering of this immense volcanic region. And I believe that the true explanation of the *Lametá* beds of which I have just been speaking, is that they were deposited in a similar way in more widely-extended lacustrine areas, previously to the commencement of the great outbreaks of lava. It need not detain us here to indicate the apparently long interval of time which elapsed during the outflowing of these successive lava streams, nor to point out how entirely different in age the *intertrappean* beds of the upper part of the series (Bombay, &c.,) may be from those which accompany the lower and older flows. None of these very much newer beds occur within the limits of the Central Provinces.

The geological epoch of these intertrappean beds seems to be tolerably well established as belonging to the *Eocene* period of European geologists; it being just possible that the lower beds of the *Lametá* group may represent a part of the upper cretaceous time. The evidence against this supposition of Mr. W. Blanford seems, however, decidedly stronger than that in its favour.

Deccan trap features.

The wondrous features of the great trappean country of the Deccan which extend over so large a portion of the surface of the Central Provinces, have been well described by many observers. The immense area covered continuously by these volcanic rocks; the enormous accumulation of horizontal, or nearly horizontal, layers of basaltic rocks; the distinct separation into beds, or stratification; the peculiar physical features,—massive flat-topped hills with sharp precipitous scarps; the abundance of beautiful zeolites and other minerals, and the occurrence of those curious intercalated beds, containing fresh-water fossils, which I have just

mentioned, could scarcely escape the notice of any observer. I have already briefly alluded to the general distribution of these rocks, so far as the Central Provinces are concerned, and shall not therefore delay further than to refer to the labours of Malcolmson, Newbold, Grant, Carter, Hislop, Medlicott, Blanford, &c., for more detailed discussions of this extraordinary series, which extends, or has extended, certainly over an area of 10 degrees of latitude by 15 to 16 of longitude. "The area covered by them in the Peninsula of India can be little "less than two hundred thousand square miles." Their limited extent within the boundaries of the Central Provinces is therefore but a very small fraction of their entire area.

Post-trappean deposits.

Of deposits later than the trappean rocks there is a great variety and an immense area. These would include all the soils of the present surface with their numerous modifications and varying agricultural value.

Laterite occurs in detached areas in Ságar and adjoining districts; it covers a considerable space in the north-east of Jabalpúr district, and is found at intervals passing to the south in Chándá, where it covers extensive areas in the eastern and north-eastern portions. It presents all the usual characters of this deposit, but nowhere within the Central Provinces attains that great thickness and massiveness which admit of its being freely used for building purposes.

Tertiary conglomerates.

The older gravels and clays of some of the river valleys would appear to be next in succession. These have been the object of more careful study, on account of the numerous remains of large animals, as well as ordinary shells, of which some of the beds contain locally in large number. The largest continuous area of these ossiferous gravels and clays is found in the Narbadá valley, along which they extend in unbroken continuity for more than a hundred miles from the falls of the 'marble rocks' near Jabalpúr to below Hoshangábád. They also occur in the banks of the river both above and below these limits. Very similar deposits are found forming the banks and often the beds of the upper feeders of the Godávarí—the Wardhá, Paingangá, &c.—and in the Godávarí itself; and here also they locally contain a large number of bones, sub-fossilised, the remains of animals which existed at the period of their deposition. The valleys of these streams are, however, by no means so well defined as that of the Narbadá, and the limits of the ossiferous gravels and clays are not easily fixed. The gravels are for the most part cemented into a conglomerate of tolerable hardness by the infiltration of carbonate of lime, and these beds might not unfrequently be mistaken for conglomerates of greatly older date on a cursory examination. There is, however, one fact which enables them to be readily distinguished, and that is the abundant presence in them of rolled pieces of the trappean rocks—of numerous agates, pieces of bloodstone, &c., which at once prove them to have been post-trappean in their origin. The immense variety and abundance of these pebbles also abundantly indicate the vast denudation to which the trappean rocks have been subjected since their outflowing and deposition.

Ossiferous gravels.

In general character these deposits in their lower portions consist of gravels and sands, frequently, as mentioned, cemented together much in the same way as a concrete is, and sometimes so hard as to be quarried for building. Towards the base the clays become sandy and pebbly. Sandy beds occur even in the clays, and irregular deposition and oblique lamination (false-bedding) are frequent—indeed so frequent as to be almost the normal condition. It is not easy to arrive at any just conclusion as to the thickness of these deposits. Actual sections of more than fifty feet in thickness are occasionally met with, but twenty to thirty feet are the more ordinary limits. The greater portion of the deposits is generally clay, the coarser beds being chiefly confined to the portion near the base. Fossil bones are not generally

abundant, but locally considerable numbers have been met with. Shells are not uncommon, and they appear to be all of species now existing in the rivers. These beds are obviously of fresh-water origin, and were in all probability the fluvio-lacustrine deposits of the rivers themselves, at a time when the levels and areas of their valleys were very different from those now existing.

It is not intended to give here a complete list of the organic remains found, which would belong rather to a detailed description. But the very remarkable admixture of existing and extinct forms which these deposits exhibit must be noticed; for along with well-preserved remains of *Hippopotamus*, *Rhinoceros*, *Mastodon*, peculiar forms of *Elephas*, and very remarkable Bovines (which, if not identical with European forms, approximate so closely that nothing but the most minute distinctions can be made, while they are entirely distinct from any present Indian forms), are found equally well preserved remains of animals still existing in the country. The not uncommon tortoise* *(Emys [Pangshura] tecta)* is found quite as fossilised in these beds as any of the other remains, and yet the species still lives in the valley itself. The imbedded shells, too, are all of species still living, and the evidence is conclusive that the change from the condition under which *Hippopotami* wallowed in the muds, and *Rhinoceros* roamed in the swampy forests of the country, where *Mastodons* abounded, and where the strange forms of the *Sivatherium*, *Dinotherium*, *Camelopardalis* existed, has been one of continuous and gradual alteration, unmarked by any great breaks or vast changes in climate. In the general series of successive epochs into which the geological periods distinguished in Europe have been classified, these ossiferous gravels and clays would seem to mark the upper portion of the *Miocene* and the *Pliocene*; while, with unbroken succession, and with nothing more than local change or break, these *Pliocene* beds pass upwards into the deposits now being formed. We thus find that numerous forms of animals, which are now contemporaries of man, existed at this very early period cotemporary with numerous forms of the larger animals now utterly extinct in this country. Was not man also cotemporary with these now extinct animals? As I have now endeavoured to show briefly, there is no physical break in the long series that would account for the destruction of these species; there is not a shadow of proof that the country was not then, as now, fitted for the abode of man. And although no human remains have yet been found, there is not a single fact which would lead to the conviction that man could not have existed and lived under the conditions which then prevailed. In this point of view, the discovery—although not in the Central Provinces—of a well-formed agate knife,† which had obviously been in use, and which was undoubtedly shaped and made with an intelligent purpose, in gravels of the same age as these ossiferous gravels of which we have been speaking and also containing remains of large animals, becomes one of the highest interest, as giving some amount of positive proof of the existence of man at this early period *(Pliocene)*.

Stone implements.

Of a later date, and scattered through the upper soils of large areas, flint (or rather agate) knives, agate cores, from which these knives have been chipped off, and numerous forms of artificially-shaped agate implements, have been met with in the Narbadá and Nágpúr country. And of a later date still, and invariably in the surface-soils, or taken out of these soils and brought together under trees, or at the rude shrines of the forest races, a large number of well-shaped and *polished* celts, axes, and other shaped stone implements have been found in the Central Provinces. The most remarkable fact perhaps connected with these implements is the identity of form and of design which they exhibit when compared with those found abundantly in Northern Europe—an identity common to both forms of these stone antiquities, the rudely-chipped and almost undressed, or, as they have been called, the Palæolithic, and the more finished and polished, or Neolithic, types.

* See Records Geological Survey of India, 1869, p. 36. † *Ibid*, 1868, p. 65.

The Central Provinces present many localities peculiarly likely to throw light, if carefully studied, on this intensely interesting question—the antiquity of man. But such inquiries can only be satisfactorily carried out by those who are long resident in the immediate vicinity, and can therefore watch the constant changes which occur, and take immediate advantage of any opportunity which may present itself.

Saline sands and clays.

Beneath the recent conglomerates and ossiferous gravels of a large portion of western Chándá is a well-marked deposit of brownish-yellow sand or clayey sandstone. This is seen over many miles of the country wherever the streams cut through the upper beds to any depth. It is not at all improbable that it may prove to be of different geological age, and quite distinct from the beds resting on it. No good sections have yet been seen. It is specially noticed here inasmuch as it contains a certain amount of salt, which is thrown out as an efflorescence where this loose sandstone is exposed to the weather, and produces miry places always wet and soft, and often difficult to cross. In connection with this deposit we may recall the occurrence of beds very low down in the alluvium, or below it, all containing a considerable quantity of common salt, in the Berár alluvial plain not far to the west of Chándá. Into this salt-bearing stratum wells are sunk for the extraction of brine, from which much salt is obtained. I am not aware of any brine-wells in the Chándá district, but this deposit contains a considerable amount of common salt, although much mixed with impurities, chiefly sulphate of magnesia (Epsom salts).* It is not impossible that the presence of common salt in sensible quantities may indicate that the clays containing it have had a marine origin, and are thus quite distinct from the beds which rest upon them.

Surface soils.

To treat of the more recent alluvial deposits of the country would involve rather more of agricultural than geological questions, and I would leave such to others more competent to enter upon them.

Regar.

The black soil or *regar*, or as it is not uncommonly called the 'cotton soil,' forms one of the most marked varieties in these provinces. It is the common soil of the Deccan, Málwá, Narbadá valley, &c. It varies greatly in colour, in consistence, and, with these, in fertility, but throughout is marked by the constant character of being a highly argillaceous, somewhat calcareous clay, being very adhesive when wetted, and from its very absorbent nature expanding and contracting to a very remarkable extent, under the successive influence of moisture and dryness. It therefore becomes fissured in every direction by huge cracks in the hot weather. It also retains a good deal of moisture, and requires therefore less irrigation than more sandy ground. The colour of this soil, often a deep and well-marked black, with every variation from this to a brownish-black, would appear to be solely due to an admixture of vegetable (organic) matter in a soil originally very clayey. Thus deposits of precisely the same character as this *regar* are being formed now at the bottom of every *jhíl* in the country, and throughout the very area where the *regar* is best marked, it is not by any means an uncommon thing to find the slopes of the small hills or undulations formed

* Two specimens of salt roughly prepared from this sandy clay by lixiviation and evaporation were assayed at the Geological Survey Office, and yielded—

Chloride of sodium	82·89	87·58
Sulphate of magnesia	16·02	11·86
Clay and organic matter	1·60	1·40

The first of these was obtained from what is called the white *chopan* soil; the second was from the dark *chopan* soil.

of more sandy reddish soil, while the hollows below consist solely of the finest *regar*. This appears to be due to the more argillaceous and finer portions of the decomposed rocks below being washed away by ordinary pluvial action from the slopes and accumulated in the hollows, where this finer mud forms a soil much more retentive of moisture, and which therefore rapidly becomes more impregnated with organic matter, and is often marshy. *Regar* can thus be formed wherever a truly argillaceous soil is formed: and its general, but by no means universal, absence over the metamorphic and other rocks is easily accounted for by the fact that these rocks for the most part yield sandy, not clayey soils. It is never of any very great depth, and, excepting when re-arranged by rivers in their recent deposits, it is therefore never met with at any great distance below the surface.

Obviously formed from the re-arranged wash of the older and more widely-extended soils we find large areas of very fertile soil, consisting of clays rather more sandy than the older alluvium, and not therefore so black or adhesive. Though rarely formed altogether of the true *regar* soil, it frequently contains a large proportion of this, mixed with other clays and sands. Every intermediate form of soil occurs, and it would by no means be an easy task to distinguish them all. In an agricultural point of view, it is interesting to see how exactly the limits of certain kinds of cultivation coincide with the limits of these marked varieties of the alluvial deposits of the country—facts which the local officers will doubtless be able to illustrate more fully than I can.

The preceding sketch has necessarily been of the briefest and most general character. Those who desire to study the geology of the Central Provinces in greater detail may refer to the many papers more or less immediately bearing on this country—of Malcolmson, (Transactions, Geol. Soc., Lond.); Hislop (Journal of Asiatic Society, Bengal; Journal of Bombay Branch Royal Asiatic Society; Quarterly Journal Geological Society, London); Medlicott, Oldham, Blanford, Theobald, (Mem. Geological Survey of India; Records Geological Survey of India), in which full details will be found so far as the country has yet been examined carefully.

I shall also leave the discussion of the economic value of the several rocks to the detailed statements of the local officers, who have infinitely better opportunity of knowing how and to what extent such materials are economised within their own districts. I have solely attempted to give as briefly as possible a general connected outline of the successive formations known to occur within the limits of the Central Provinces, trusting that this outline may be filled in with greater detail by future researches.

N. B.—The following papers bearing on the Geology of the Central Provinces have been published since the foregoing was written:—

The coal-field near Chándá, Central Provinces.—Records, Geol. Surv., India, 1869, p. 94.
Lead in Ráípúr district, Central Provinces.—*Ibid*, p. 101.
On the lead vein near Chicholi, Ráípúr district.—*Ibid*, 1870, p. 44.
The Wardha river Coal-fields, Berar and Central Provinces.—*Ibid*, p. 45.
Coal at Korba in Bilaspúr district.—*Ibid*, p. 54.
Mohpani Coal-field.—*Ibid*, p. 63.
Lead ore at Slimanabad, Jabalpúr district.—*Ibid*, p. 70.
Coal east of Chhattisgarh in country between Bilaspúr and Ranchí.—*Ibid*, p. 71.
The plant-bearing sandstones of the Godávarí valley; on the southern extension of rocks belonging to the Kámthí group to the neighbourhood of Ellore and Rájámandri, and on possible occurrence of coal in same direction.—*Ibid*, 1871, p. 49.

ADDITIONAL NOTE ON THE PLANT-BEARING SANDSTONES OF THE GODÁVARÍ VALLEY, *by* W. T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey of India.*

Since writing the paper in this volume of the "Records," p. 49, I have found that the occurrence of sandstone near Ellore was mentioned by Voysey, Jour. As. Soc., Bengal, Vol. II, 1833, p. 400. Both Voysey and Walker refer in several places to the occurrence of sandstone in the valley of the Godávarí below Sironchá, so that Wall was not the first to make it known, although he appears to have been the first who explored its extent on the river banks. In explanation of my mistake, I should mention that my paper was written when I was encamped on the Godávarí without a single book of reference available.

I have also ascertained that the sandstone which extends to the neighbourhood of Ellore is connected with the large tract to the north-west by a narrow strip about six miles broad to the west of Palúncha, thus confirming Voysey's statement on the authority of a Mr. Ralph (Jour. As. Soc., Bengal., Vol. XIX, p. 290). The sandstones, therefore, extend, apparently without a break, from Mangli and Phizdúra, 60 miles south of Nágpúr, to within a few miles of Ellore, or nearly 300 miles in a direct line.

The boundaries of this enormous tract are in many parts most imperfectly known: by far the greater portion of the area consists of rock in which no trace of coal has hitherto been detected, and in which the occurrence of the mineral is highly improbable. It is along the edges that there is the best chance of valuable discoveries being made.

Since writing the paper above alluded to, I have visited Alápali, a village about thirty miles west of Dúmagúdem on the Kinarswámi stream, at which I had been informed by one of the officers of the Nizam's Government, the Naib of Naganienpol, that some coal had been discovered. Mr. Vanstavern, Executive Engineer of Dúmagúdem, had, at my request, sent some specimens of the coal found at Lingálá to the Naib for distribution amongst the minor officials, and for enquiry as to the occurrence of a similar mineral throughout the great sandstone country on the right bank of the Godávarí. This resulted in a report of the occurrence of coal near Alápalí, but on visiting the spot, I found that all which had been found consisted of fragments brought down by the stream. I had not time to trace these to their source, and this was the less necessary, as I found that an officer of the Nizam's Government had been sent from Warangal in order to do so. I have since been informed by the Tehsildár of Kamarmet that the spot has been found. It is some distance to the east of Paikhal on the confines of the Kamarmet and Warangal Sircars. This discovery will not be of much value at present if any permanent supply can be found on the Godávarí below the second barrier, but should no such supply exist, the locality near Paikhal will be well worthy of attention. The fragments of coal found in the Kinarswámi are shaly and of inferior quality, but where this exists better coal may, of course, be found.

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" " " Specimen of the rock of which Pompey's pillar is constructed.

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HIND, HENRY YOULE.—Report on the Sherbrooke Gold District, with a Paper on the Gneisses of Nova Scotia, 8vo., 1870, Halifax.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1871. [November.

ABSTRACT OF RESULTS OF EXAMINATION OF THE AMMONITE-FAUNA OF KUTCH, WITH REMARKS ON THEIR DISTRIBUTION AMONG THE BEDS, AND PROBABLE AGE, by WILLIAM WAAGEN, PH. D., *Geological Survey of India.*

IN preparing for the "Palæontologia Indica" a monograph of the fossil Cephalopoda and in particular of the AMMONITIDÆ, represented in the Kutch Jura, I have obtained some general results, which may be interesting to notice in connection with the study of the jurassic deposits in that province.

The Cephalopoda seem rather common in all the principal jurassic strata of Kutch, excepting in the lowest beds, which have as yet furnished only some Gastropods, a great number of Pelecypods, besides some undeterminable fragments of Belemnites and a few other fossils.

The number of species of *Ammonites* collected by Messrs. Blanford, Wynne, and Fedden, in the course of a few working seasons, amounts to about 80, of which number, however, all are not in a sufficiently good state of preservation to allow of accurate determination. According to the different genera, which have been lately distinguished in supercession of the old genus "*Ammonites*," the following are represented in the Kutch Jura: 5 species of *Phylloceras*, 2 of *Lytoceras*, 1 *Haploceras*, 6 *Oppelia*, 6 *Harpoceras*, 7 *Peltoceras*, *(n. g.)* 4 *Aspidoceras*, 17 *Stephanoceras*, and about 32 *Perisphinctes*. If we inquire into the geological distribution of those genera in the European jurassic districts, we will find that the *Phylloceras* and *Lytoceras* are not limited to certain strata of the jurassic formation, but begin in the Trias, and extend without any interruption into the middle, and even upper layers of the Cretaceous period. *Haploceras*, on the contrary, occurs within narrower limits, appearing solitary for the first time in the Bathonian, and disappearing again in the lowest beds of the Neocomian, its principal development being in the Tithonian group. Of the genus *Oppelia* the greatest number of species is found in Oxfordian and Kimmeridgian beds, furnishing only a few sporadic species in lower strata, and beginning in the Inferior Oolite. *Harpoceras* is characteristic for the Lias, but extends, however, in well developed forms up into the Oxfordian, and even into the Kimmeridgian group. *Peltoceras* is chiefly an Oxfordian, *Aspidoceras* chiefly a Kimmeridgian and a Tithonian genus. *Stephanoceras* occurs through the whole Jura, whilst *Perisphinctes*, represented by a larger number of species and specimens than any of the other genera, is mostly characteristic for the Upper Jura.

If we now consider the number of species, by which every single genus is represented in the Kutch Jura, the simple comparison of the numbers before given, with the facts known regarding the geological position of the genera in Europe as stated above, will show us

clearly, that at least a part of those jurassic strata must belong to the Upper Jura, unless we presume that the faunæ have followed laws of distribution quite different from those which were prevalent during the time of the jurassic deposits in Europe.

Proceeding to the species, I will give brief distinctive characters of the new forms which I have described. There are of *Phylloceras*, preserved in the Geological Survey Museum,—

Phylloceras disputabile, Zitt. (golden oolite of Keera hill near Charee; brown oolite of the Jooria hills).
„ *Lodaiense*, Waagen, n. sp. (brown oolite of Lodai).
„ *Feddeni*, Waagen, n. sp. (oolite with iron nodules near Dhosa).
„ *ptychoicum* Quenst. (coarse iron sandstone of the Katrol range).
„ *Zignodianum*, Orb. (golden oolite of Keera hill).

Phylloceras Lodaiense, Waagen, n. sp. Very closely allied to *Phyll. disputabile*, Zitt., but the furrows disappearing on the siphonal side and very deep near the umbilical margin; it has also much shorter and broader lobes than *Phyll. disputabile.*

Phylloceras Feddeni, Waagen, n. sp. Closely resembling *Phyll. Homairei*, Orb., but the umbilicus a little smaller and the external saddle finishing in three unequal leaves. It differs from *Phyll. euphyllum*, Neum., by a little larger umbilicus and less developed third leaf on the external saddle.

The genus *Lytoceras* has furnished, as stated before, only two species, one of them being new; they are:

Lytoceras Adeloides, Kudern. (golden oolite of Keera hill).
„ *rex*, Waagen, n. sp. (sandy yellow rock, S. of Charee).

Lytoceras rex, Waagen, n. sp. A specimen of 600 m m. in diameter. Inner whorls finely striated without any prominent ribs; body-chamber with a few prominent ribs, with broad smooth spaces between them; ribs with 7 folds on each side.

The species of *Haploceras* which I have mentioned before is not determinable with sufficient certainty, as the last part of the body-chamber is wanting; but it is very probably

Haploceras tomephorum, Zitt. (coarse sandy iron rock, S. of Boojooree).

The genus *Oppelia* has furnished several well known European species of great interest, only two new forms were among the number. The species are:

Oppelia subcostaria, Opp. (golden oolite, Keera hill).
„ *glabella*, Leckenby (gray marl nodule, Keera hill).
„ *trachynota*, Opp. (coarse sandy iron rock, Katrol range).
„ *Cutchensis*, Waagen, n. sp. (same layer and locality).
„ *plicodiscus*, Waagen, n. sp. (rock indistinct, S. of Madapoor).
„ cf. *serrigera*, Waagen (gray limestone, S. of Nurrha).

Oppelia Cutchensis, Waagen, n. sp. Very much like *Oppelia compsa*, Opp., however much smaller; the siphonal side rounded, granulated; tubercles on the body-chamber scarce, distant, rounded; ribs entirely disappearing.

Oppelia plicodiscus, Waagen, n. sp., belonging to the group of *Oppelia subtililobata*, W. and nearly allied to *Opp. tenuilobata*, Opp. The shell is small and covered with rather broad, strongly falciform ribs, which are a little swollen at the middle of the sides; near the siphonal margin a great number of very fine, short ribs, which are not in connection with the others, are visible.

Among the species of the genus *Harpoceras,* there is a single European form; all the other species are as yet known only from the Indian Jura. The species are:

Harpoceras hecticum, Rein. (golden oolite, Keera hill).
" *ignobile,* Sow. (yellow limestone, Keera hill).
" *crassefalcatum,* Waagen, n. sp. (same layer and locality).
" *Orientale,* Orb. (rock indistinct, Keera hill).
" *fornix,* Sow.
" *Nurrhaënse,* Waagen, n. sp. (iron nodule, Nurrha).

Harpoceras crassefalcatum, Waagen, n. sp., resembles very much *Harp. ignobile,* Sow., but the whorls are depressed; the ribs much stronger, less numerous and much more irregular; the species is also of smaller size, when adult.

Harpoceras Nurrhaënse, Waagen, n. sp. Allied to *Harp. lunula,* Rein., but the ribs which cover the sides of the shell are much finer and sharper, and much more curved than in the last mentioned species.

Peltoceras, Waagen, n. gen. This genus is, I consider, very closely allied to *Aspidoceras,* Zitt., and possibly only a sub-genus of it. It is established for the species which Zittel in his last volume on the Tithonian fauna has separated from his genus and united with *Perisphinctes,* but I think the relation between those forms believed to belong to *Perisphinctes* and *Aspidoceras perarmatum,* as he calls this Ammonite, are much closer than the relations between them and the true *Perisphinctes,* though contractions of the whorls also occur in the former species. I am disposed to consider in this case the form of the lobes as the most important distinguishing character. Thus, for instance, in *Amm. Arduennensis* and *Amm. perarmatus,* the lobes are nearly identical in both species, the first lateral lobe being so much enlarged that the second lateral lobe becomes nearly obsolete; and as this form of lobes never occurs in the true *Aspidoceras* (as *Asp. iphicerum* and others) nor in the true *Perisphinctes* (as there the auxiliary lobes have another position), I think it reasonable to separate those species with this particular shape of lobes under a distinct generic designation. The genus *Peltoceras* is, therefore, characterised by the *particularly enlarged lateral lobe, a discoid, largely umbilicated shell; the whorls sometimes with contractions, always covered with strong straight ribs, which are sometimes provided with two or three rows of spines; siphonal side more or less flattened or even excavated, ribs crossing over or disappearing before they reach the siphonal part of the shell. Aperture more or less rectangular.* Thus characterised, I believe, the genus should include the groups of *Pelt. Arduennense, transversarium, perarmatum, hybonotum* and a few other, less known, forms. The species of this genus occurring in the Kutch Jura are:

Peltoceras athleta, Phill. (gray marl nodule, N. of Goodjinseer).
" *aegoceroides,* Waagen n. sp. (brown oolite of the Jooria hills).
" *Arduennense,* Orb. (same layer and locality).
" *semirugosum,* Waagen, n. sp. (brown oolite of Lodai and the Jooria hills).
" *bidens,* Waagen, n. sp. (same layer and locality).
" *perarmatum,* Sow. (brown oolite of Lodai and Jooria, and doubtful from the red sandy iron rock of Kuntkote).
" *monacanthus,* Waagen, n. sp. (coarse yellow sand rock, Katrol range).

Peltoceras aegoceroides, Waagen, n. sp. A very small species, with many thin somewhat rounded whorls and numerous simple ribs which cross the siphonal side undivided; whorls barely touching each other.

Peltoceras semirugosum, Waagen, n. sp. This species becomes extremely large, and in that form closely resembles *Pelt. perarmatum,* Sow. Young specimens, however, have almost

entirely the form of *Pelt. Arduennense*, Orb., with the single difference, that the ribs, which are, as long as they exist on the shell, divided into two branches nearly from the umbilical margin, are stronger and less numerous. Growing larger each rib is produced at the point, where it passes from the lateral to the siphonal side, into a prominent spine, from which the rib proceeds regularly over the siphonal side. In yet larger specimens a second row of spines appears also near the umbilical margin, the ribs become then nearly obsolete, and fragments are only distinguishable from *Pelt. perarmatum* by the peculiar flattening of the ribs which connect the corresponding tubercles of both the umbilical and perispherical rows.

Peltoceras bidens, Waagen, n. sp. Very much resembling the former species, but distinguishable by the ribs being mostly undivided and very coarse; they are provided on the siphonal side with two indistinct tubercles. Large specimens have more distant spines than *Pelt. semirugosum.*

Peltoceras monacanthus, Waagen, n. sp. Allied to *Pelt. hybonotum*, Opp., but with only one row of spines near the umbilical margin, and less distinct granulations on both sides of the median excavation on the siphonal side.

The genus *Aspidoceras*, though represented in our Museum by a good many fragments, has furnished only two determinable species; they are:

Aspidoceras iphicerum, Opp. (red, fine sandy iron rock, N. of Dhosa).
" *Wynnei*, Waagen, n. sp. (coarse sandy iron rock, at Toodoora, S. of Boojooree, together with *Hapl. tomephorum*) in the highest layer containing *Ammonites*).

The other fragments are from the coarse iron sandstone of the Katrol range, and appear to be referable to *Asp. iphicerum*, Opp., and *binodum*, Quenst.

Aspidoceras Wynnei, Waagen, n. sp. Most nearly allied to *Asp. Apenninicum*, Zitt., but the outer row of tubercles stronger, and more numerous; and in general more irregular than in the species just quoted.

The genus *Stephanoceras* is extremely rich in forms in the Kutch Jura, but notwithstanding this, it only represents there a single group, the Macrocephali. Several sub-divisions among the species belonging to the genus can be distinguished, facilitating the determination of the species themselves. I distinguish (1) a group of species, allied to the true *St. macrocephalum*, (2) a group of species with bent ribs on the siphonal side, which replace in India the group of *St. goverianum*, &c., of Europe, (3) the group of *St. modiolare*, represented in India but by a single species.

To the first group belong the following species:

Stephanoceras macrocephalum, Schloth. (golden oolite of Keera hill, brown oolite of Jooria, grayish yellow marl rock of Jumara).
" *tumidum*, Rein, (golden oolite, Keera hill).
" *Polyphemus*, Waagen, n. sp. (common in the brown oolite of Lodai, Jooria and N. of Goodjinseer, very rare in the golden oolite of Keera hill).
" *lamellosum*, Sow. (golden oolite, Keera hill; ? yellow sand rock, N. of Dhosa).
" *Chareeënse*, Waagen, n. sp. (golden oolite, Keera hill; yellow marl rock, Jumara).
" *Grantanum*, Opp. (same rocks and localities as the preceding sp.; also in a sandy iron rock at Kaora, Putchum).
" *elephantinum*, Sow. (brown oolite, Lodai).
" *arenosum*, Waagen, n. sp. (same rock and locality).
" *? Maya*, Sow. (red iron rock, Kuntkote).

Stephanoceras Polyphemus, Waagen, n. sp. This species grows enormously large, 1½ feet in diameter, and seems identical with d'Orbigny's drawing of *St. tumidum* (Orb. non Rein.). It differs from the real *St. tumidum* by very broad rounded ribs and a smooth body-chamber, while Reinecke's species has fine sharp ribs and a plicated body-chamber.

Stephanoceras Chareeënse, Waagen, n. sp. Allied to *St. Morrisi*, Opp., but much broader near the umbilicus and with a very narrow siphonal side, on account of which the transversal section of the whorl is nearly triangular. There are also some differences in the sutures.

Stephanoceras arenosum, Waagen, n. sp. Of a very flat lenticular form, with faint, broad rounded ribs somewhat resembling *St. Lalandeanum*, Orb., but the ribs are not undivided, and only few of them reach to the umbilical margin. The lobes are also quite different.

The second group includes the following species:

Stephanoceras dimerum, Waagen, n. sp. (golden oolite, Keera hill; gray marl rock, Jumara; sandy iron rock, Kaora; doubtful, Jooria).
„ *subtrapezinum*, Waagen, n. sp. (golden oolite, Keera hill).
„ *eucyclum*, Waagen, n. sp. (brown oolite, Keera hill, Jooria hills).
„ *opis*, Sow. (iron nodules, Keera hill; brown oolite, Jooria; oolite, Dhosa).
„ *fissum*, Sow. (red iron rock, Kuntkote; brown oolite, Lodai, Jooria; oolite, Dhosa; iron nodule, Keera hill).
„ *Nepalense*, Gray (red iron rock, Kuntkote; brown sandstone, Trummo river).

Stephanoceras dimerum, Waagen, n. sp. Allied to *St. Herveyi*, Sow., but with smaller umbilicus and with the ribs curved in front on the siphonal side. The ribs are broad and prominent; the general shape of the specimens somewhat globular. Body-chamber with strongly curved, high, lamellose ribs. The species attains scarcely more than a diameter of 50-60 m m.

Stephanoceras subtrapezinum, Waagen, n. sp., very much like the preceding species, but with much finer ribs, and with flattened sides of the whorls; the aperture having a somewhat trapezoidal shape and the form of the whole shell being more lenticular. It attains a little larger size than the preceding species.

Stephanoceras eucyclum, Waagen, n. sp. Full grown specimens with preserved body-chamber have a slight resemblance to similarly preserved specimens of *Cosmoceras ornatum* or *Duncani*, but the examination of the inner whorls shows that the species belongs to *Stephanoceras*. The umbilicus is very wide, the whorls a little compressed, and covered with polytome fine ribs; the lobes are very short and broad.

The last group of *Stephanoceras* is that of *Steph. modiolare*, Luid., only represented in Kutch by a single species.

Stephanoceras diadematum, Waagen n. sp. (golden oolite: Keera hill).

Stephanoceras diadematum, Waagen, n. sp. The species attains nearly one foot in diameter. Full grown specimens are entirely smooth, and closely resemble large individuals of *St. modiolare*, Luid., except that the umbilicus is always wider; small specimens, however, are entirely different, as they never have the "Lamberti-like" shape, which characterises young individuals of the last mentioned species. *St. diadematum* has always very broad, depressed whorls, which are covered in the first youth with dichotome ribs becoming afterwards polytome, and passing with a slight curvature in front over the flat siphonal side; the lateral lobes are situated on this latter portion of the shell.

The genus *Perisphinctes* has furnished, of all the Ammonites, the greatest number of species, and I regret that the European species of this genus are as yet so little known, that in many cases a comparison of our fauna with the forms found in European strata becomes utterly impossible. The forms of *Perisphinctes* found in Kutch may be conveniently divided into a few larger sections, which I may call after the oldest and best known species, without, however, assigning these sections the value of developmental series (Formenreihen, Entwickelungsreihen). I distinguish (1). *A section of forms, related to Per. Königi,* Sow.; the species to which I refer represent a connecting link between the last mentioned species and *Per. Rolandi, Frischlini,* and other Ammonites of the European Upper Jura. The whole section ranges between the true *Perisphinctes* and *Stephanoceras*, and, following the external form, it could almost with equal right be referred to the one or the other of the two genera. (2). *Section of forms allied to Per. Martiusi,* Orb. The species of this section chiefly occur in middle Jurassic and Callovian beds, and their number was recently considerably increased by the description of new forms in Europe. The latest representatives of it in Europe are known from Oxford strata. (3). The species of this section are *allied to Per. plicatilis,* Sow., and are chiefly from Oxfordian and Kimmeridgian beds. (4). *Section of forms allied to Per. Rehmanni,* Opp. A small series of species with a very peculiar shape, in many points entirely separated from all the other *Perisphinctes*, and chiefly characteristic for the Callovian. Besides these there occur in the Kutch-Jura also some other species which cannot be referred to any of those sections, and which must for the present be looked upon as sporadic, or isolated species.

The first section, characterised by the great scarcity of contractions on the whorls, mostly without any umbilical edge, and by thick scarce ribs, includes the following species from Kutch:

Perisphinctes obtusicosta, Waagen, n. sp. (oolite of Dhosa; iron nodules of Keera hill; gray marl nodules, N. of Goodjinseer).
„ *angygaster,* Waagen, n. sp. (same rocks and localities as preceding species).
„ *Dhosaënsis,* Waagen, n. sp. (oolite of Dhosa; brown oolite of the Jooria hills; iron nodule, Keera hill).
„ *mutans,* Waagen, n. sp. (dark red iron rock, N. of Goodjinseer).

Perisphinctes obtusicosta, Waagen, n. sp. Slightly resembling *Per. Rolandi,* Opp., but with less numerous and rounder ribs, which are not divided so far down as in the last mentioned species; in large specimens the ribs become flatter and more numerous. The lobes are much finer and more ramified than in *Per. Rolandi.*

Perisphinctes angygaster, Waagen, n. sp. In its general form resembling *Per. involutus,* Quenst., but with only dichotome ribs, which are few in number and obtusely rounded; in some places there is a broad, flat, contraction of the whorl visible. The lobes are very much like those of the preceding species.

Perisphinctes Dhosaënsis, Waagen, n. sp. A small species of about 40 m m. in diameter, with wide umbilicus, rounded whorls and very strong dichotome ribs, which often become a little broader in passing over the siphonal side, resembling the ribs in some *Aegoceras* or in *Amm. fissicostatus,* to which latter species our specimens have a certain resemblance as regards their general form. The lateral margins of the aperture have two not very long lancet-shaped ears. The species seems to be common.

Perisphinctes mutans, Waagen, n. sp. Young specimens of this species have a certain resemblance to *Per. Dhosaënsis,* but the form changes even at an early stage: the whorls

become compressed, the ribs flattened, and the body-chamber of a specimen of 60 m m. in diameter (about the largest size the species appears to attain) is nearly quite smooth.

The section of *Per. Martiusi* is represented in the Kutch Jura by nine determinable and at least four, as yet undeterminable, species, the latter being in our Museum only indicated by fragments, not sufficient for a reliable definition of the species. The better known species belonging to this section are:

Perisphinctes spirorbis, Neum. (golden oolite, Keera hill).
" *bracteatus*, Neum. (same beds and locality).
" *funatus*, Opp. (same beds and locality).
" *paramorphus*, Waagen, n. sp. (same beds and locality).
" *arcicosta*, Waagen, n. sp. (same beds and locality).
" *curvicosta*, Opp. (oolite of Dhosa; marl nodules, Goodjinseer; yellow marl rock, Jumara).
" *euryptychus*, Neum. (hard yellow limestone, Keera hill).
" *Pagri*, Waagen, n. sp. (red iron rock, Kuntkote).
" *Gudjinsirensis*, Waagen, n. sp. (marl nodules, Goodjinseer).

Perisphinctes paramorphus, Waagen, n. sp. A remarkable species, which undergoes great changes according to age. When quite young, the whorls are rounded and slightly involute, covered with strong, few, and dichotomous ribs; middle sized specimens have a slightly squarish section of the whorls, these being more involute and covered with moderately numerous, strong bipartite ribs. Growing only a little larger than 100 m m. in diameter the whorls become rather high oval with a narrowly rounded siphonal side, and the ribs disappear entirely; in this stage the species resembles large specimens of *Per. spirorbis*.

Perisphinctes arcicosta, Waagen, n. sp. An intermediate species between *Per. aurigerus*, Opp., and *curvicosta*, Opp. The whorls are compressed like those in the former species, whilst the kind of ribbing agrees more with that of the latter. The largest size to which the species attains is about 60—70 m m. in diameter. In such specimens the body-chamber is but slightly ribbed and the lateral ribs are disconnected from those situated on the siphonal side.

Perisphinctes Pagri, Waagen, n. sp. In its general form very nearly allied to *Per. Orion*, Opp., but with less strongly prominent and more numerous lateral ribs; the ribs on the siphonal side are slightly turned backwards.

Perisphinctes Gudjinsirensis, Waagen, n. sp. A species also belonging to the group of the Convoluti, but certainly one of the most extraordinary forms of the whole group. The whorls are very depressed and the umbilicus large. Young specimens are of the usual habit, but fuller grown ones become provided with high, distant lateral ribs, which are divided into three flat branches on the depressed siphonal side. Full-grown specimens do not exceed a diameter of 100 m m.

In connection with the few last mentioned forms I shall describe three species, which are as yet unknown from European jurassic formations, and which are, strictly speaking, more geologically than zoologically related to the former. They are:

Perisphinctes frequens, Opp. (oolite of a valley, west of Soorka hill, together with *Rhynch. myriacantha*).
" *denseplicatus*, Waagen, n. sp. (same layer and locality).
" *aberrans*, Waagen, n. sp. (white marl rock, Keera hill).

Perisphinctes denseplicatus, Waagen, n. sp. Very nearly allied to *Per. frequens*, Opp., but with a somewhat smaller umbilicus, higher whorls, and much finer lateral ribs, which

are never tripartite on the outer margin, but sometimes bipartite and sometimes cross undivided over the siphonal side.

Perisphinctes aberrans, Waagen, n. sp. The only species with which I can compare this form is *Per. Albertinus*, Cat., but the difference lies in Catullo's species possessing a furrow on the siphonal side when young, while there is no trace of it in the present species. The dissimilarity, however, between young and old specimens of *aberrans* is by no means less marked than in *Per. Albertinus*. The young form resembles a little *Per. convolutus;* it has many separate rounded whorls, with fine ribs and tolerably numerous very oblique contractions of the whorls. When growing larger the ribs of the individual become in an equal degree more distant, stronger and higher on the sides of the whorls, whilst, on the contrary, they gradually disappear on the siphonal side.

The third section (of *Per. plicatilis*, Sow.) is the richest in forms in the whole Jura. In Europe it is represented by at least 100 species, all occurring in strata of Oxfordian, Kimmeridgian or Tithonian age, but for the greater part the species are as yet undescribed. The difficulty, therefore, not only in determining, but in comparing the Indian species with European forms, is much greater in this section than in any other, and the conclusions, which in other groups and genera are so naturally associated merely with their names, can in this instance not be drawn from the identity of the species, but only from the general habitus of the forms; however, some of the Indian species can nevertheless be identified with European Ammonites. The species belonging to this section are:

Perisphinctes Indogermanus, Waagen, n. sp. (brown oolite, Jooria hills; yellow marl rock, Joorun).
„ *plicatilis*, Sow. (red iron rock of Kuntkote; same rock at Joorun).
„ *torquatus*, Sow. (coarse iron sandstone of the Katrol range).
„ *bathyplocus*, Waagen, n. sp. (same layer and locality).
„ *Pottingeri*, Sow. (same layer and locality).
„ *euplocus*, Waagen, n. sp. (same layer and locality).
„ *Katrolensis*, Waagen, n. sp. (same layer and locality).
„ *virguloides*, Waagen, n. sp. (red iron rock of Kuntkote).

Perisphinctes Indogermanus, Waagen, n. sp. Very nearly allied to *Per. plicatilis*, Sow., and often mistaken for this species, but distinct from it by rounded whorls and flattened ribs on the siphonal side. There are specimens in our museum from Kutch as well as from Trouville in Normandy (Zone of *Am. cordatus*).

Perisphinctes bathyplocus, Waagen, n. sp. Allied to *Per. torquatus*, Sow., so much so that young specimens are almost undistinguishable. *Per. bathyplocus* has, however, always finer ribs and thicker whorls. When large, the lateral parts of the ribs are much swollen and distant from each other, and to each of them correspond five or six fine ribs on the siphonal side; only in very large specimens the latter become obsolete, or very nearly so.

Perisphinctes euplocus, Waagen, n. sp. Allied to *Per. Pottingeri*, Sow., but with much thinner whorls, and S-shaped, irregular, fine ribs. On the body-chamber the ribs become scarcer, more prominent and straight.

Perisphinctes Katrolensis, Waagen, n. sp. Equally allied to *Per. Pottingeri* as the last, but attaining a much larger size, and with the body-chamber much less strongly ribbed.

Perisphinctes virguloides, Waagen, n. sp. Closely resembles *Per. virgulatus*, Quenst; the ribs are, however, not so fine and the contractions of the shell indistinct.

The next species belongs to a group which is of great importance for the geology of the European Jura: it is—

Perisphinctes leiocymon, Waagen, n. sp. (red iron rock of Kuntkote).

The group is typified by *Per. polyplocus*, Rein. This latter species is known in Europe to be very characteristic for the Kimmeridgian, and not alone that, but the whole group is restricted to a similar horizon. It is doubtful whether in India the geological position is exactly the same, but nevertheless *Per. leiocymon* deserves particular notice.

Perisphinctes leiocymon, Waagen, n. sp. Closely allied to *Per. polyplocus*, Rein., but with much fainter ribs and of by far larger dimensions; only the ribs are near the umbilical margin somewhat more strongly marked. The species shows also by its rounded ribs some slight resemblance to *Per. albienus*, Opp., and thus the Indian species may be said to represent a connecting link between the section of *Per. Martiusi* and the *Polyploci* group.

The last section of *Perisphinctes* is that of *Per. Rehmanni*, Opp. The species belonging to it usually possess spiny whorls and a flat band along the middle of the siphonal side. Though I think the section originates with *Per. sulcatus*, Hehl., I quote as the first species *Per. Rehmanni*, because the geological relations between those two species have not as yet been established. The Indian species belonging to the section are:

Perisphinctes Rehmanni, Opp. (golden oolite, Keera hill).
" *anceps*, Rein. (iron nodules, Keera hill; oolite, Dhosa).
" *arthriticus*, Sow. (iron nodules, Keera hill).
" *Jooriensis*, Waagen, n. sp. (brown oolite, Jooria hills).

Perisphinctes Jooriensis, Waagen, n. sp. Allied to *Per. Balderus*, Opp., but more evolute, with less numerous contractions on the whorls and sharper and more regular ribs.

The 73 species above enumerated have been determined and described from the materials in our Museum with sufficient certainty. Several forms I was obliged to put aside, partly because the materials were in bad preservation, and partly because there was not a sufficient number of specimens existing, in order to point out the exact relations or distinctions of the species; this is particularly the case among the *Perisphinctes*.

The oldest known locality where Ammonites occur, and at the same time the richest in forms, is the Keera hill near Charee, and the mineralogical differences of the rocks in which different species are preserved clearly indicate that there must be several distinct groups of middle and upper jurassic strata exposed. This variety of the rocks cannot be accidental, as is, for instance, shown by *St. tumidum* or *Per. funatus*, which never occur in an iron nodule, while *Per. arthriticus* has never been found in the golden oolite. Of the different beds in this locality, containing different Ammonite-faunas, I can at present point out two, each with a sufficiently large number of species, the golden oolite and the bed with iron nodules; all the other strata are represented only by a few species:—

(1.) Ammonites of the *Golden Oolite* of *Keera hill* near Charee:

Phylloceras disputabile, Zitt.
" *Zignodianum*, Orb.
Lytoceras Adeloides, Kud.
Oppelia subcostaria, Opp.
Harpoceras hecticum, Rein.
Stephanoceras macrocephalum, Schloth.
" *tumidum*, Rein.
" *Polyphemus*, Waagen.
" *lamellosum*, Sow.
" *Chareeënse*, Waagen.
Stephanoceras Grantanum, Opp.
" *dimerum*, Waagen.
" *subtrapezinum*, Waagen.
" *diadematum*, Waagen.
Perisphinctes spirorbis, Neum.
" *bracteatus*, Neum.
" *funatus*, Opp.
" *paramorphus*, Waagen.
" *arcicosta*, Waagen.
" *Rehmanni*, Opp.

Of these species *Ph. disputabile*, Zitt., *Zignodianum*, Orb., and *Lyt. Adeloides*, Kud., are known to be characteristic in the mediterranean province of the jurassic formation of Europe for a group of strata beginning with Bathonian and most probably terminating with lower Oxfordian rocks. The following species indicate a much more narrowly limited horizon: *Steph. macrocephalum*, Schloth., *tumidum*, Rein., *Grantanum*, Opp., *Perisph. spirorbis*, Neum., *bracteatus*, Neum., *funatus*, Opp., and *Rehmanni*, Opp., all without exception in the central European province are highly characteristic for the lower Kellovian beds, or the "zone of *St. macrocephalum*" of Oppel. The Ammonite-fauna of the 'Golden Oolite' shows very little resemblance to the faunas of other localities, and in fact there are only three species which are common to this layer and the brown oolite of Lodai and the Jooria hills; those are *Phyll. disputabile, St. macrocephalum* (very rare at Lodai), and *Polyphemus* (very rare at Keera hill). It seems to me that the characteristic species of the Ammonite-fauna of this Golden Oolite appear again only at Kaora in Putchum, and at Jumara, though similar rocks may be often represented in different horizons throughout the Kutch jurassic territory.

2). Ammonites of the *Iron nodules* of *Keera hill* near Charee—

Stephanoceras opis, Sow.
,, *fissum*, Sow.
Perisphinctes obtusicosta, Waagen.
,, *angygaster*, Waagen.
,, *Dhosaënsis*, Waagen.
,, *anceps*, Rein.
,, *arthriticus*, Sow.

The greater part of these species also occurs at the two next localities, and I shall, therefore, quote those occurring in the two latter immediately following.

(3). Ammonites of the *Oolite* of *Dhosa*—

Stephanoceras opis, Sow.
,, *fissum*, Sow.
Perisphinctes obtusicosta, Waagen.
,, *angygaster*, Waagen.
,, *Dhosaënsis*, Waagen.
,, *curvicosta*, Opp.
,, *anceps*, Rein.

(4). Ammonites of the dark-gray *marl nodules, Goodjinseer*—

Peltoceras athleta, Phill.
Perisphinctes obtusicosta, Waagen.
,, *angygaster*, Waagen.
,, *curvicosta*, Opp.
,, *Gudjinsirensis*, Waagen.

There is, I think, but little doubt that the Ammonite-fauna of these three localities indicates very closely the same geological horizon, particularly when we consider the small number of specimens (there are in our Museum not more than about 60 specimens preserved from all the three localities) which were examined, and that these have furnished so many identical species.

Of the species noticed, the following are found in the European Jura: *Pelt. athleta, Perisph. anceps* and *curvicosta*; all three are most characteristic forms of the upper Kelloway strata.

The next localities which have furnished a greater number of species are Lodai and the Jooria hills. The rock containing the fossils is a very fine, often sandy dark-brown

oolite with much iron, and the Ammonite-fauna of both places is so very closely allied that it will not be necessary to quote the species separately.

(5). Ammonites of the "*Brown oolite*" of *Lodai* and the *Jooria hills*—

Phylloceras disputabile, Zitt.	*Stephanoceras Polyphemus*, Waagen.
„ *Lodaiense*, Waagen.	„ *elephantinum*, Sow.
Peltoceras aegoceroides, Waagen.	„ *arenosum*, Waagen.
„ *Arduennense*, Orb.	„ *eucyclum*, Waagen.
„ *semirugosum*, Waagen.	„ *fissum*, Sow.
„ *bidens*, Waagen.	*Perisphinctes Dhosaënsis*, Waagen.
„ *perarmatum*, Sow.	„ *Indogermanus*, Waagen.
Stephanoceras macrocephalum, Schloth.	„ *Jooriensis*, Waagen.

Of *Phyll. disputabile* I have already mentioned the geological position; among the other species in the list it may seem a little strange to find together, apparently in the same layer, *St. macrocephalum* and *Pelt. perarmatum*. The discrepancy may be explained in two ways. Either there exist in Lodai and Jooria two layers of very similar lithological aspect, but of different age, or *St. macrocephalum* had in India a greater vertical distribution than in Europe, that is, the species passes in India from lower into higher strata, during the deposition of the latter of which it was already extinct in Europe. The latter explanation seems to me the more plausible one, because there occurs also in another locality, at Kuntkote, a species of the *Macrocephali*, (*St. Maya*, Sow.,) which is so closely allied to *St. macrocephalum*, that it is hardly possible to distinguish them specifically, and also because in Kutch the *Macrocephali* group in general seems to continue, in a great variety of forms, into higher beds than is the case in Europe. Under these circumstances, we may, therefore, consider as the most valuable species for determining the age of the strata above noticed the species of the *Peltoceras*, which in Europe are highly characteristic for lower and middle Oxfordian. The most important species are *Peltoc. Arduennense* and *perarmatum*, and next to these *Per. Indogermanus*, which is very common in the "zone of *Am. cordatus*" of the "Vaches noires."

The brown oolite has, in common with the oolite of Dhosa, *Steph. opis* and *fissum*, whilst on the Keera hill we again find *St. eucyclum* in an indurated yellow limestone, together with *Per. euryptychus*, Neum., which possibly could represent the brown oolite in that place.

The locality west of Soorka hill has furnished only two species of Ammonites—

Perisphinctes frequens, Opp., and
„ *denseplicatus*, Waagen,

associated with *Rhynch. (Hemithyris) myriacantha*, Desl., in a brown oolite, very much like that of Lodai.

The next locality of considerable geological interest is that of Kuntkote, because Sowerby has described from there several species, and among them *Per. calvus*, which was most probably wrongly identified with one occurring in Europe; but unfortunately no specimen of true *A. calvus*, Sow., is found among our materials. The rock of Kuntkote is dark-red, fine sandy, ferruginous, much impregnated with salt and gypsum. The species are—

(6). Ammonites of the *red ferruginous rock* of *Kuntkote*:

Peltoceras cf. *perarmatum*, Sow. (possibly *Pelt. Oegir*, Opp.)
Stephanoceras Maya, Sow.
„ *fissum*, Sow.
„ *Nepalense*, Grav.

Perisphinctes Pagri, Waagen.
„ *plicatilis*, Sow.
„ *virguloides*, Waagen.
„ *leiocymon*, Waagen.

These few species can serve merely by their general character as a guide towards the determination of the age of the Kuntkote beds, because the only species of which the geological position is well known in Europe, *Per. plicatilis*, indicates only generally strata of lower or middle Oxfordian age. The other forms of *Perisphinctes* occurring at Kuntkote resemble in general character such species as, if found in Europe, would be referred to the middle or upper Oxfordian. This and the appearance of the rock leads me to believe that the Kuntkote beds are a little younger than the brown oolite, with which they have only a single species, *St. fissum*, in common. A similar rock to that of Kuntkote occurs only at a certain distance north from Dhosa, where *Aspidoceras iphicerum*, Opp., has been found in a dark-red and a slightly sandy ferruginous rock.

The last locality of importance which has furnished nearly the greatest number of specimens of Ammonites, though the number of species is not very large, is the Katrol range, the rocks there being represented chiefly by coarse ferruginous sandstones and sandy ferruginous concretions, with frequent occurrence of fossil wood. The species found there are—

(7). Ammonites of the coarse *ferruginous sandstone, Katrol range:*

Phylloceras ptychoicum, Quenst.
Haploceras cf. *tomephorum*, Zitt.
Oppelia trachynota, Opp.
„ *Cutchensis*, Waagen.
Peltoceras monacanthus, Waagen.
Aspidoceras Wynnei, Waagen.
„ 2 sp. indet.
Perisphinctes torquatus, Sow.
„ *bathyplocus*, Waagen.
„ *Pottingeri*, Sow.
„ *euplocus*, Waagen.
„ *Katrolensis*, Waagen.

The first three species are European forms, and two of them, *Phyll. ptychoicum* and *Hapl. tomephorum*, are very characteristic for the Tithonian formation of the Mediterranean Jurassic province, whilst *Opp. trachynota* occurs in the middle and upper Kimmeridge and Tithonian layers of the Mediterranean and Central European provinces. Of the other species, only *Pelt. monacanthus* and *Asp. Wynnei* have a decidedly Tithonian character, whilst among the *Perisphinctes*, the absence of the group of *Per. polyplocus* also indicates very high jurassic beds. It should also be mentioned that Mr. Fedden notes on the label accompanying the specimens of *Asp. Wynnei* and *Hapl.* cf. *tomephorum*—"From the highest beds containing *Ammonites.*"

Recapitulating briefly what I have said regarding a few of the principal localities containing *Ammonites*, it seems clear (1) that at different places there are strata of a different mineralogical character represented; (2) that these strata contain species of *Ammonites* mostly peculiar to themselves; and (3) that these species indicate distinct geological horizons.

If we take only those species into consideration which occur in the Kutch, as well as in the European Jura, we find that in the golden oolite of Keera hill there are nine species of the "zone of *St. macrocephalum;*" in the oolite of Dhosa and the equivalent beds there are three

species of the "zones of *Perisph. anceps* and *Pelt. athleta;*" in the brown oolite are three species of the "zone of *Am. cordatus*" and one of the "zone of *St. macrocephalum.*" In the ferruginous rock of Kuntkote there is one species common to the "zones of *Am. cordatus* and *Pelt. transversarium;*" and, lastly, in the coarse sandstone of the Katrol range are two species of the Tithon-formation and one common to middle and upper Kimmeridgian and Tithonian.

If, therefore, the faunas have not in their development in India followed other laws than they did in Europe, we might arrange the deposits of the whole of the Kutch Jura in the following manner:

Rocks.		Localities.	Probable equivalents in Europe.
Ferruginous sandstone	coarse ...	Katrol range	Tithonian and Upper Kimmeridgian.*
	fine ...	Kuntkote	Upper Oxfordian.
Oolite		Lodai and Jooria	Lower Oxfordian.
		Dhosa	Upper Kelloway.
		Golden oolite ... ... Keera hill.	Lower Kelloway.
Flaggy, sandy limestone and yellow sandstone		Guddera (Ammonites wanting) ...	Bathonian.

The most general division we could at present introduce into the Kutch Jurassic deposits is to separate them into two complex groups of sandstones, divided from each other by a zone of oolites of comparatively small thickness.

But there remains yet the great question, what is Mr. Wynne's "Upper Jura of Kutch" which contains the plants, of which several are considered as identical with those of the Rajmahal hills, for all the beds which I have previously noticed, and which appear to represent the jurassic deposits of Europe from the Bathonian upwards to the Tithonian, compose only the "Lower Jura" of Mr. Wynne's divisions, based on the physical relations of the beds. To answer this question satisfactorily in the present stage of our knowledge is impossible; we must be content to wait the result of further research into the fossils to be found in this interesting province.

THE RAIGUR AND HENGIR (GANGPÚR) COAL-FIELD, by V. BALL, *Geological Survey of India.*

The coal-field thus denominated has hitherto been generally spoken of as the 'Gangpúr field.' The result of my examination having been to show that the greater portion of the area is contained in the district of Raigur and the remainder in the sub-zemindari of Gangpúr known as Hengir (or Hingir)—no portion of the coal-bearing rocks or their associates extending into Gangpúr proper—it seems undesirable to perpetuate a misnomer which is only calculated to mislead.

Whether this area is entirely detached from the Údípúr field or not I am at present unable definitely to affirm. My impression is, that a connection does exist towards the north-

* The Lower Kimmeridgian is only represented by a single species, *Asp. iphicerum,* from N. of Dhosa out of a dark-red fine sandy ferruginous rock.

west, but where I crossed from one to the other there was an interruption of continuity caused by a strip of about four miles of metamorphic rocks. These may possibly only exist as a spur from the southern boundary, which, while they penetrate the area of sedimentaries, do not extend sufficiently far north to cause an absolute separation of the two fields.

Approaching this field from the west, I first struck it about a mile, or rather less, east of the village of Bagchapa on the Kurket in Raigur, and thence traced it to its extreme eastern extension at Kosira on the Baisandar in Hengir. The distance between these points is 34 miles in a direct line. So far as my time admitted, I examined the country to north and south, and at many points ascertained the definite boundaries. At others I was obliged to content myself with conjecture, but from such data as I possess I feel confident that the area occupied by the three groups of sedimentary rocks which occur in this field will be found to extend over at least 400 square miles.

With this introduction I shall, before proceeding to the actual details resulting from my preliminary examination, briefly allude to such previous notices as exist regarding the occurrence of coal and coal-bearing or associated sedimentaries in this area.

Colonel Haughton, 1854.*

Colonel Haughton alludes to the Gangpúr coal formation as possibly connected with that of Sirguja and Palamow, but adds, "on this point I have no reliable data."

Captain Saxton, 1855.†

Captain Saxton communicated to the Asiatic Society in 1855 some particulars regarding coal in the Gangpúr Raja's territory, some 50-60 miles north-west from Sumbulpúr and 25-30 miles from Puddumpúr on the Mahanudi. He writes, "should Calcutta and Bombay be hereafter connected by railway this coal would lie on the way. The bed appears very extensive. A nalá running into the Ebe river which joins the Mahanudi about ten miles above Sumbulpúr passes over, and through, it, and masses of the upper coal which is very light are floated down in the nalá in the rains."

No further precise information regarding the locality is given, though little doubt can exist that the Baisandar is the 'nalá' alluded to.

Dr. Oldham.

In a preliminary notice on the coal and iron of Cuttack by Dr. Oldham, reference is made to this discovery by Captain Saxton. Time did not admit of the Officers of the Geological Survey—at that season engaged in Cuttack—visiting the locality.

Topographical Survey Map.

On the Topographical Survey Map, recently published, the occurrence of coal is indicated in several localities, especially in the Baisandar river.

The formations occurring in this area are Tálchírs, Barákars, and Upper sandstones, &c., (? Mahadevas).

TÁLCHÍRS.

The only place at which I met with rocks belonging to the Tálchír series in this field was near the village of Kosira at the north-east corner of the area; they are very indistinctly seen, and much mixed up with a kind of *arkose* bed, which is precisely similar to one occurring on an undoubted Barákar horizon, and which will be found described further on. In the Baisandar below Kosira they consist of greenish and yellow sandstones with a boulder bed.

* J. A. S., B., 1854.

† Proc. A. S., B., March, 1855.

Mr. Medlicott found Tálchírs all along the southern boundary of this area striking north-west from Sumbulpúr, but I had no time to connect these with my work.

BARÁKARS.

The Damúda rocks occurring in this area probably belong to the Barákar group. For the most part they rest immediately on the gneiss, and are covered and overlapped by the upper sandstones and grits so completely that but for the denuding action of rivers they would now be altogether concealed. This is more particularly the case in the eastern portion of the area where the best coal seams occur. Thus, in the Baisandar and Jhajia rivers the Barákars are merely exposed in the beds, while the upper rocks compose the opposing banks.

It will be more convenient to describe the sections from east to west; I therefore commence with that of the Baisandar river.

In the bed of the Baisandar, the most eastern outcrops of Barákars occur south of Kosira. From this point the northern boundary of the field can be most distinctly traced through the southern *tolah* of Tikripara ; the south-eastern boundary is less distinct, but I am inclined to believe that a strip of Barákars, bounded by the gneiss on the east and by the upper sandstones on the west, occurs at least as far south as the village of Balingá.

The section of the Baisandar for about a mile west of Kosira discloses ordinary Barákar sandstones and the arkose bed above alluded to ; this consists of granitic and schistose materials not showing any sign of having been subject to weathering. Beyond these rocks there is a succession of rolling seams of carbonaceous shale with occasional bands of coal ; these strike with the boundary, but as they are all nearly horizontal, constant repetitions occur in succeeding streams, and I had not time to trace out the section in sufficient detail to enable me to affirm positively how many distinct seams exist. The first promising seam which I measured occurs 250 yards south of the Jhapurnga and Tikripara road crossing. The following is the section :—

Descending : dip 15° to 30° south of east.

		Ft.	In.
	SANDSTONES.		
1.	Blue shales	3	4
2.	*Coal*	4	7
3.	Irregular mass of blue shale	2	6
4.	*Coal*, upper portion shaly	3	10
5.	Parting	0	2
7.	*Coal*, about	5	0
	Several feet below not well seen.		

The coal in this seam at first sight looked very promising, but on analysis it has proved to be of inferior quality, the proportion of ash being 30·6. I very much fear that there is at present no promise of coal of better quality and of workable thickness being found in this neighbourhood. Below is a seam of 80 feet of carbonaceous shale with portions coaly. This could not be measured without excavations being made, for which there was no time. But it gives no promise of containing a workable thickness of coal.

The reaches above this expose the top of a fine seam of carbonaceous shales with coaly bands. The strike being with the stream, a very peculiar terraced appearance is produced. Above its junction with the Jhajia the course of the Baisandar is from north to south, and thus a very distinct section is obtained of one of the largest seams which has been recorded as occurring anywhere.

It is most unfortunately deficient in workable thicknesses of good coal. The following is the section :—

Ascending.

		Ft.	In.
1.	Coarse grit sandstones with interpolated carb. shales ...	0	0
2.	Blue and sandy shale	2	0
*3.	Inferior coal with partings of carb. shales, central portion all coal	6	10
	Carried forward ...	8	10

		Ft.	In.
	Brought forward ...	8	10
4.	Sandstone (thinning out to 0)	1	8
5.	Blue and black shales with occasional coaly layers of 1 inch and less	5	5
6.	Ditto, more coaly, but useless	2	0
7.	Blue shales	0	7
8.	Papery *coal* and coaly shale	4	1
9.	Blue shale concretionary	1	10
10.	Carb. shale passing into coaly shale	5	6
11.	Blue concretionary shale	5	8
12.	Carb. shale with flaky *coal*	4	10
13.	Blue concretionary shale	1	8
14.	Carb. shales	0	8
15.	Flaky *coal*	2	0
16.	Blue concretionary shales	0	8
17.	Carb. shales, portions coaly	2	9
	Same decomposed	3	6
18.	Blue concretionary shales—Dip south south-east 4° ...	6	0
19.	Carb. shale and flaky *coal*	1	10
20.	Blue concretionary shales	1	9
21.	Flaky carb. and coaly shale with charcoal markings, coaly portion containing much red oxide of iron...	1	6
22.	Blue concretionary shale	2	10
23.	Stony *coal* very impure	1	2
24.	Ditto, portions flaky...	1	3
25.	Flaky carb. shale	2	0
26.	Blue concretionary shale	4	7
27.	*Coal* with red oxide of iron	1	10
28.	Carb. shale	0	3
29.	Flaky coaly shale	1	0
30.	Blue shales	1	2
31.	Flaky carb. shales—portions coaly—Dip 4° south south-east ...	7	0
32.	Carb. shales	1	3
33.	Same as 31	2	6
34.	Blue concretionary shale. Dip south 6° (corner of bend) ...	1	11
35.	Impure *coal* much mixed with red oxide of iron and passing into flaky coal and carb. shales	3	10
36.	Concretionary shale	2	7
37.	Flaky *coal* with iron	0	10
38.	Carbonaceous shale	1	2
39.	Concretionary blue shale	1	3
40.	Carb. shale and coaly shale	1	9
41.	Blue shale	1	4
42.	Carbonaceous shale and stony *coal*	1	10
43.	Flaky *coal* with carb. shale	3	6
44.	Concretionary blue shale passing into pinkish carb. shale ...	3	8
45.	Flaky *coal* with carb. shale	1	3
46.	Blue concretionary shale	3	8
47.	*Coal* permeated with iron	1	2
48.	Flaky *coal*, about	2	0
49.	Concretionary blue shale	3	0
50.	Carbonaceous shale and flaky *coal* ... ... 1' 4" to	2	0
51.	Massive sandstones irregularly interpolated and thinning out to south	10	10
52.	Carbonaceous shales	0	8
53.	Coaly shale containing much iron and alternating with carb. shales	2	0
54.	Blue and black concretionary shale	9	0
55.	Same as 5	0	9
56.	Concretionary blue shale	7	0
57.	Concretionary blue and black shales with concretionary layers. Dip 4° south	12	0
	This is on southern bank of Baisandar.		
	TOTAL ...	168	7

This seam is also seen in the streams west of the village of Sardega, but not so clearly as in the Baisandar.

Below No. 1 of the above seam there are some Barákar grits, and underneath them some arkose beds, which plaster over granitic gneiss, showing a most distinctly natural boundary.

There are no traces of coal or other sedimentary rocks brought down from further north by the Baisandâr. This, though not a *proof* that none such exist, may be taken as collateral evidence in favor of the view —also supported by the physical characters as represented on the map—that uncovered gneiss continues up to the plateau and is connected with the main gneiss of Eastern Udípúr, &c.

In the bed of the Jhajia river westwards, the large seam becomes much broken up by interpolations of sandstones and shales, and with the dying out of the more coaly bands the change is so complete that it is impossible to recognise it or trace any portion of it through successive reaches. Between Ratansarai and Ghogarpali there are several seams or repetitions of a seam, but none contain coal of useful quality and thickness. As above mentioned, the upper sandstones appear on either bank, and in one place occupy the bed of the stream itself. South of Ghogarpali there is a seam containing about 30 feet of shale to one of coal. Above the village it is seen again, a portion having been burnt: in the unburnt part there is a band of 8 inches of very good coal and several thinner layers. About 25 feet in all of this seam is exposed at this second locality.

Between this and Bograkachar there are frequent outcrops of carbonaceous shale with coaly layers belonging to several distinct seams. Close to Bograkachar there is a seam of similar character with a slight indication of a dip to east south-east. The contained coal is in very thin layers. How far these rocks may extend northwards up the bed of the river I had not time to ascertain, but from the pebbles I think it probable that the gneiss cannot be very far distant.

This little area of carbonaceous rocks which occupies the beds of the Baisandar and Jhajia rivers may be best understood by regarding it as a vast seam of some 500 feet of coaly and carbonaceous shale with irregular partings and interpolations of sandstones. Occasional thin bands of good coal occur, but they are rare, and the prevailing components of the seam are blue and black carbonaceous shales.

The prominence and abundance of the outcrops are such that no one could possibly avoid noticing the coaly looking beds which are particularly well exposed in the vicinity of the road crossing at Tikripara.

As to the extension of these seams southwards underneath the upper sandstones nothing certain is at present known, and should it be found that the latter rest immediately on the Tálchírs of the south boundary, then it will be impossible to solve this question without having recourse to borings.

The centre part of this field is traversed by two principal streams, the Koldiga and the Kelo, with a number of smaller tributaries. The high ground between these is probably for the most part occupied by outlying patches of the upper sandstones, while in the river beds Barákar rocks are exposed.

Kelo Section.—In the river section between Jhargaon and Hokra there are several outcrops of seams consisting of carbonaceous shale. Only one, that near Tiptipa, contains coal, but even there it is in too small quantity to be of any use. At Hokra there is a 10 foot seam of concretionary shale, no coal—dip 4° to 35° east of south.

Beyond the Gari Ghât there is a 2 foot seam of concretionary shale and coal—dip 7° south.

In the Bendia (near the mouth), which joins the Kelo at Gari, there is a considerable seam.

Ascending—Dip irregular, south-west 5°.

	Ft.	In.
1. Carb. shales, bedding irregular, with some slight coaly layers towards base	4—5	0
2. *Coal*, portions flaky, but for the most part burnable, much weathered	4	10
3. Parting, ferruginous sandstones	0	6
4. Flaky *coal* with carb. shale excessively weathered and decomposed	6	0
	15 4—16	4

I think it possible that some good coal might be extracted from this seam. In its present decomposed condition even, it is easy to see from the manner of weathering that good or fair coal exists. The thicknesses given above do not hold for all parts of the seam. In this same stream (Bendia) higher up a rolling seam of carbonaceous shale with a few inches of coal continues on both sides for about half a mile.

Between this and the village of Korukel there are three seams consisting of blue shales, the most southern of which contains some layers of good coal 6 inches thick.

Returning to the Kelo section. At the top of the next reach beyond the mouth of the Bendia there is a seam containing 12—15 feet of blue and black shales with coaly layers—dip 4° to 30°, south of west.

In the next mile and a half four or five seams are met with; they are apparently repetitions of those above alluded to in the Bendia; none of them contain any useful quantity of coal.

At Milupara there is a change in the dip to more or less north of west, and two or three seams are exposed with intervals covered. Sandstones are the only rocks seen up to Khara, but near the village there are some greenish fine sandstones which I at first thought might be Tálchírs, but they appear to overlie the carbonaceous shale. Near Khara there were still fragments of coal in the stream, which showed that the northern limit of the Barákars had not been reached. There were also, however, a quantity of gneiss fragments which had not the appearance of having travelled any great distance. The hills formed of the upper sandstones impinge close on the banks of the river in this neighbourhood.

Koldiga Section.—In the Koldiga below Mahulai there are rolling carbonaceous shales with ironstones and flaggy beds, but I did not see any coal. The whole aspect of these rocks reminded me more of the "*carbonaceous shale and ironstone group*" than of any other rocks of the Damúda series which I have elsewhere met with. I am not, however, prepared to say at present whether they are susceptible of separation from the Barákar group.

Between the Samkera and Parega and Samkera and Gasbahari road ghâts the flags accompanying the carbonaceous shales present a very peculiar appearance, being of green buff and grey colors, sometimes resembling Tálchírs, but always closely connected with the carbonaceous shales.

East of this the section consists principally of carbonaceous shales up to Dumartoli, where the stream falls from the higher ground occupied by the upper sandstones.

Much remains in this area to be done in the detailed separation of the Barákars from these upper rocks. Except where there are marked physical features, owing to the slightness of the contrast in lithological characters, it is extremely difficult to draw a satisfactory boundary.

West from the Kelo the coal-bearing rocks are found for a distance of 13 miles.

In the Pájú river there are some fragments of coal brought from some seam or seams north of the high road, but none are exposed in its immediate vicinity.

In the Dighi stream at Deogurh there is a seam of blue and black carbonaceous shales with 5 inches of coal at the top. No better seam is exposed in the river for a mile to the south.

In the Hurinara stream there are sandstones and some traces of coaly and carbonaceous shales. Between the valleys of Simra and Charatanga there are some ferruginous sandstones, possibly Barákars. Between Charatanga and the Kurket river there are Barákar sandstones, and the same are better seen in the bed of the river itself. The section examined in both directions north and south for about half a mile showed no signs of coal *in situ*, but fragments occur in the bed of the stream.

The boundary of these rocks must cross the Kurket about midway between the villages of Rábo and Bágchapa.*

Bágchapa itself is on gneiss, and about a mile to the south the boundary of the Vindhyans is marked by a low range of hills.

Upper Sandstones.

The manner in which, especially in the eastern portion of this field, the coal-bearing rocks have been covered by the upper sandstones has been already alluded to. The principal area of these rocks exists south of the strip of Barákars which are exposed at the drainage level by the rivers and streams. How far it extends southwards is not known, and the important economic question as to the extension of the coal measures underneath has still to be determined. If it be found that the Barákars crop out from beneath them and rest on the Sumbulpúr Tálchírs described by Mr. Medlicott, then the question will be solved, but if, as is possible, and in some degree probable, the upper sandstones lap over on to the Tálchírs without any appearance of Barákars intervening, then the extension of the latter can only be ascertained by borings.

North of the Barákar sections the upper sandstones form large hills, sometimes resting on the former and sometimes resting immediately on the gneiss, as is particularly well seen in the valley north of Jhanjgir. The lithological characters of these rocks are very much the same as they were in the northern fields—highly ferruginous sandstones and grits, and red brown and ochreous clays sometimes with fragments of plants. The bedding is for the most part horizontal, and apparently does not partake of the rolling which characterises the underlying Barákars.

Description of the sandstones in the neighbourhood of the first barrier on the Godávarí, and in the country between the Godávarí and Ellore, by William T. Blanford, F. G. S., *Deputy Superintendent, Geological Survey.*

A brief notice of the great sandstone tract in the valley of the Godávarí and its tributaries has already been given in the Records of the Geological Survey of India for 1871, pages 49—52. The following pages furnish a somewhat more detailed account of the south-eastern portion of this area, extending from the junction of the Tál with the Godávarí to the alluvium of Yelaur (Ellore) and Rájámahendrí.

The only portion of the country which has been closely examined is the area occupied by the Damúda rocks, which are seen in the Godávarí just below the junction of the Tál, and again about 30 miles lower down the river near the village of Deorpalí and Ganara on the left bank, and of Amravâram, Damarcherla, and Mádavâram on the right. The remainder

* As I had no map whatever of this country, I did not attempt any detailed examination.

of the sandstone tract, consisting principally of Kámthí beds, has been more cursorily surveyed. Tálchírs occur in several small patches, mostly isolated, in the immediate neighbourhood of the river.

The description commences at the northern extremity of the area, at the confluence of the Tál and Godávarí. The various rocks seen on the banks of the latter river between the Tál and Bhadráchalam are noticed in succession, then the sandstones around Ganara and Deorpalí north of the Godávarí; and the remainder of the paper is composed of notes on the sandstone tract extending from Mádavaram and Palúnchá on the north to the coast alluvium on the south, commencing at the north-east corner near Mádavaram.

The country has hitherto attracted but little attention from Indian Geologists: a portion of it is briefly described in Dr. Voysey's Second Report on the geology of Hydrabad* and in the extracts from his private journals ;† and the sandstones on the river banks are noticed by Mr. Wall in his "Report on a reputed coal formation at Kota."‡ But none of these papers do much more than to mention the existence of sandstone or other rocks in particular spots.

It may be as well briefly to mention the features of the Godávarí valley above the mouth of the Tál. From Sironchá the river runs through sandstones as far as the commencement of the second barrier just above the confluence of the Indraotí river with the Godávarí. Here it enters metamorphics, the sandstones (Kámthí, &c.,) occupying the country to the south-west. At the bottom of the barrier, after traversing a band of Vindhyan quartzites, the river enters the plant-bearing sandstones, and they are the only rocks seen upon its banks from this point to the mouth of the Tál, but at a short distance inland from the left bank a high range of Vindhyan quartzite runs parallel with the river, and terminates, a few miles before reaching the Tál, not far from the large village of Charla, whilst the quartzites and their associates extend as far as the Tál, and re-appear south of it. On the right bank of the river the sandstones stretch for a considerable distance, much farther than on the left.

All the country between Charla and the Godávarí appears to be alluvial; no rock is seen in the river bank for a long distance above the mouth of the Tál.

Rocks near Charla.

On the road from Charla to Tiagra (Tengra) Tálchírs are seen about a mile from the Tál. Some more are met with in the jungle to the eastward; but between the road and the Godávarí none were detected. At Charla itself, nothing could be seen on the surface, and the hills to the eastward are of Vindhyan sandstone, but blocks of unmistakeable Kámthís have been dug out from the north side of the village to repair the tank. There can, I think, be but little doubt that these are in place, and, if so, both Damúdas and Tálchírs, which appear to the southward, must here be overlapped.

Rocks near mouth of Tál just above Lingálá.

In the branch of the Godávarí east of the island (char or lanka) above the mouth of the Tál one solitary block of coarse conglomerate is seen. Precisely similar rocks come in, dipping at about 17° to the west at the spot where the Tál joins the Godávarí. At this place fragments of coal have been picked up, but despite much search, borings through the sand, &c., their source had not been discovered until after I had left the country.§ Three hundred or 400 yards above its mouth, Tálchírs appear in the Tál, dipping

* J. A. S., B., 1833, Vol. II, p. 392.

† Id. 1850, Vol. XIX, pp. 287-288 and 296-302.

‡ Mad. Jour. Lit. and Sci., 1857, Vol. XVIII, p. 256.

§ Since I left the Godávarí, Mr. Vanstavern has cut into a small seam of coal under the rocks on the north side of the Tál at its mouth. It is about a foot thick and very shaly. This is doubtless the source of the coal found at this spot.

at a high angle to the westward, and the same rocks recur at intervals for about three miles; then limestone belonging to the Vindhyans makes its appearance. This limestone has been employed in the anicut and locks at the first barrier.

Above Tiagra the Tálchírs seem not to extend far east of the bed of the Tál, metamorphics appearing near the stream on the right bank. On the left bank a hill of Vindhyan sandstone appears just above Keshúpúr. The range of hills east of Tiagra, extending to Halverú, are of Vindhyan quartzite, east of which metamorphics occur. To the west of them Tálchírs are seen near Tiagra, but to the southward all is alluvium between the road to Dúmagúdem and the river.

Rocks on banks of Godávarí near Lingálá.

Along the (left) banks of the Godávarí below the mouth of the Tál, reefs of typical Damúda sandstone, more or less conglomeratic, run parallel with the bank to some distance south of Lingálá. The dip is west, and west by south,—at Lingálá W. 30°—40° S.,—with an inclination of 17° to 20°. These beds abound in Vindhyan pebbles and detritus, by which they are coloured quite red in some places. Small seams of coal have been found amongst them by Mr. Vanstavern in two or three places, but none exceeded 2 feet in thickness, and they can be traced a short distance only. Reefs of similar rocks occur in the river at a distance from shore, and beneath one of them a seam 5 feet thick was found by Mr. Vanstavern.

At Omadháram, below Lingálá, the river bank falls back to the eastward, and the strike of the rocks turns to the south, and then south-west, crossing the river. Beneath the lowest reef of Damúda conglomerate seen is some fine sandstone, probably belonging to the Tálchírs. Below this no rocks are seen on the left bank of the river for more than three miles. About two and a half miles above Parnasálá metamorphics appear, and continue as far as Dúmagúdem.

Rocks south-west of the Godávarí near Managúr.

Above the spot, at a village called Tarkala Singaram (Ryechelgoodium on one map) where the Damúdas appear on the right bank opposite Lingálá, striking across the river, no rocks are seen in the river bank as far as Biaram, a distance of eight or nine miles, and the country near the river bank consists of alluvium. Further inland rock crops out here and there, but much of the surface is covered with sand or sandy clay. On the road from Managúr to Mangampet coarse felspathic sandstone is seen in two or three places. There is a hill of conglomerate dipping westward, south-west of the village of Románjá, and coarse sandstone and conglomerate is seen near Pyáran Tank. The hills west of Managúr consist of similar beds, white and brown in colour. The sandstone has the same loose pseudo-vesicular texture which is seen in some of the Kámthí beds, and in one spot hardened clay is intermixed with the rock as at Sironchá. The dip is low to the west or west by north.

Rock is exposed here and there throughout the thick jungle with which all the country is covered, except in the immediate neighbourhood of the river bank. Some small pits were made and borings put down near Singaram, and sandy shale and clays, white, pale buff, pink and brown, were met with, some of those cut into in the pits containing *Glossopteris*. The beds seen at Singaram must be a continuation of the Damúdas seen at Lingálá,

Rocks near Singaram.

but it is impossible to say how much, if any, of the coarse sandstones and conglomerates seen west of Managúr should be ascribed to this group. Judging from the other rocks found to the south-east, a large proportion of these beds are probably Kámthí, and there is every appearance of the Damúdas being overlapped by the Kámthís near Managúr, as they are in all probability at Charla.

Rocks on right bank of Godávarí below Singaram.

The beds seen in the river bank at Singaram are brown and white sandstones, evidently Damúdas, and the prolongation of the rocks seen at Lingálá. Their dip varies, being usually W. 10° to 20° N., and about 20°, but it ranges from 10° to 30°, and is difficult to make out exactly. Down the river, Tálchírs come in about half a mile or rather less below Singaram and 200 yards west of the village of Yegúradigúdem, and dip north-west about 12°. They are thence seen in the river bank at intervals for about three and a half miles, as far as a little village called Raigúdem. Here the last outcrop of Tálchírs occurs at a small jutting point; metamorphics appear about 200 yards further down the river, near the houses of the village. A hill not more than 100 yards from the river bank is of Vindhyan quartzite, but in the river itself only metamorphics are met with. The dip of the Tálchírs is somewhat irregular, but chiefly to the north-west, and a considerable area must be exposed.

Country west of Godávarí near Dúmagúdem.

The country west of the river from this to Bhadráchalam was only very cursorily examined. The great ridge of Ratangota running north-east to south-west is of Vindhyan quartzite; it is isolated, being bordered by metamorphics on the south-east, and partly on the north also; while to the west and south-west Tálchírs occur, and a belt of them extend from its southern extremity to the Godávarí at Dúmagúdem, the village of Mitagúdem resting upon these beds. Vindhyans re-appear in the hills south and south-east of Mitagúdem; they form the hill about a mile west of the Godávarí opposite Dúmagúdem, and extend south as far as Gondigúdem, and thence for an unknown distance to the westward. They are much hardened, and the softer beds are rather schistose. The southern boundary of the plant-bearing series runs from Ratangota hill westwards through Búga, where there is a hot-spring; all Damúdas and Tálchírs disappearing and massive Kámthís abutting against the Vindhyans. From near Búga the boundary runs south-west through a very wild jungle, metamorphics replace the Vindhyans, the latter not being found to the southward so far as the rocks were examined, whilst the area of the plant-bearing sandstones extends for an unknown distance to the west towards Paikhal.

Rocks in Godávarí near Dúmagúdem.

The anicut of the first barrier opposite Dúmagúdem is on metamorphics, but just below Tálchírs come in, apparently continuous with the larger area to the westward. They occupy the river bed for rather more than a mile, and are seen on both banks, but do not appear to extend to the eastward. They are quite characteristic, mudstones and fine sandstones; the dip is variable. Just below Amágarpali some coarse gritty hard sandstone is exposed, dipping north-west; it is unusually coarse for Tálchírs, being even conglomeratic.

Inaccuracy of map.

The map west of the river is very inaccurate, and the two banks by no means coincide. Just below the anicut, the right bank is marked too far south or down the river by 200 yards, whilst a mile farther down points on the right bank are a quarter of a mile farther north than those which are really opposite to them on the left bank.

Tálchírs south of Dúmagúdem.

A small exposure of Tálchírs is seen on the right bank of the river at Sinterál, two miles or rather more below Dúmagúdem; another on the opposite bank (perhaps part of the same) just below. The latter extends for about a mile east of the river. Tálchírs again occur on the left bank just above Dáutheram point, which is of granitoid metamorphics, and a mile and a half below they are seen for a mile along the left bank, not extending across to the right. They, however, stretch inland, to the eastward for about six miles.

The lowest beds seen on the river bank west of Narsápúr are compact fine grained sandstone dipping north-east and resting with pseudo conformity, as not unfrequently happens, on the metamorphics. South of Narsápúr, and a little east of the river bank, close to a small nalá, this fine sandstone has been quarried to some extent for the navigation works at Dúmagúdem. It cuts well, but has been found to have a great tendency to split and crumble after exposure.

East of Narsápúr the ordinary shales or mudstones prevail. Boulders, some of them of great size, abound on the road from Narsápúr to Bandalgúdem. One must have been nearly 10 feet in diameter. The larger blocks are metamorphic, but smaller pieces are of Vindhyan sandstone and limestone.

Metamorphics near Bhadráchalam.

From Tárbáká near Narsápúr to Raigúdem, on the right bank of the Godávarí, close to the mouth of the Pámálerú, four miles below Bhadráchalam, only metamorphic rocks are seen in the Godávarí. In Malcolmson's Map* Deccan overlying trap is represented as occupying a considerable area on both sides of the river close to Bhadráchalam. I have not been able to trace the source of Malcolmson's information, but it must have been founded on the large quantity of hornblendic gneiss occurring at Bhadráchalam and in the neighbourhood. Some of this is so compact as to become mineralogically a greenstone.

Trap on Malcolmson's Map.

Banks of Godávarí below Bhadráchalam.

The north or left bank of the Godávarí is composed of metamorphic rocks until close to the village of Deorpalí, whilst the south or right bank consists of sandstone from Raigúdem, the boundary between the two, which appears to be a fault, running along the channel of the river. The hot spring at Gundala, temperature 140°, is concealed beneath the sand of the river, and a small well is annually made in the sand in order to reach it. This is done at a feast in the month of April. The position of the spring is apparently a little north of the boundary between the metamorphics and the sandstone, but as very few rocks are seen, the exact position of this boundary is uncertain.

Hot spring of Gundala.

Sandstones below Deorpalí.

From Deorpalí sandstones occur, wherever any rocks are exposed, on both banks of the river, with one exception, as far as Nándigúr on the left bank, and a little below Mádaváram on the right. The exception is on the latter for about a mile and a half above the village of Poláram, where metamorphics appear. Below Mádaváram no sandstones are known to occur.

The sandstones around Raigúdem, Deorpalí, Mádaváram, &c., are part of the great area extending southwards to the neighbourhood of Ellore and Rájámahendrí, which has been briefly described in the Records of the Geological Survey for 1871, p. 49. A full detail of the boring operations is given in the same volume of the Records, p p. 59-66.

Arrangement of notes on the sandstone area.

In proceeding to describe the geological features of the sandstone area extending from Raigúdem, Deorpalí, and Mádaváram on the north to the alluvium of Ellore, it will be most convenient first to give such notes as have been made on the small tract north of the river near Deorpalí, next those on the isolated area to the south around Mádaváram, and finally a brief account of the large extent of sandstone extending to the southward from Raigúdem and Palúncha.

* Geol. Trans., Ser. 2, Vol. V, pl. XLVII.

Sandstones north of Godávarí near Deorpalí.

In the small sandstone area extending along the north or left bank of Godávarí from Deorpalí to Nándigúr but little rock is exposed, except in the hills near the first named village, the greater part of the ground being thickly covered with river alluvium. The sandstones extend inland from one to two miles from the river bank, and consist principally of Damúdas, Tálchírs being seen at or outside of the northern boundary in two places, whilst the rocks forming the Deorpalí hills are probably of Kámthí age. It is possible that this tract and the corresponding one south of the river around Mádaváram are faulted in places, as some of the few dips seen are confusing and anomalous.

Sandstone tract near Deorpalí.

The exact position of the eastern boundary is, in great measure, undetermined. The first rocks exposed are in the Nandi Vágú* near Nándigúr. In this, for about half a mile from the Godávarí, fine yellow felspathic sandstone is seen in places, dipping at a considerable angle to north-west by west, that is, in the direction of the boundary. Metamorphics occur to the eastward, but not in the immediate neighbourhood of the stream. The last sandstone seen to the northward in the stream bed has low but irregular dip. Above this no rock is seen for more than a mile, but sandstones probably occur, because rolled pebbles of quartz, &c., are abundant west of the stream and south of the village of Nálagúnta. Metamorphics make their appearance in the Nandi stream nearly due east of this village.

No sandstone whatever is seen in place between the Nandi stream and the Ganár, but metamorphic rocks crop out to the north. Two boreholes put down north of the village of Ganara entered quicksands at depths of 34 and 22 feet respectively, and it was found impracticable, after sinking in the first instance through 18 feet, and in the second through 24 feet of loose sand and water, to penetrate to the rock. In the Ganár Vágú Damúdas are seen in two or three places about half to three quarters of a mile from the mouth, and in a boring at one of these coal was discovered (see Records, 1871, pp. 61-62). Above this metamorphics appear, but still further north Tálchírs are met with, and extend north for about a mile towards the villages of Malipúr and Kishtáram. They are almost, if not entirely, separated from the Damúdas, metamorphics intervening not only in the stream, but to the east of it, while to the west the surface is much covered by alluvium.

West of the Ganár stream sandstone is exposed in several places near the village of Tátpali and south of Egerpeta, but the dip is obscure. Apparently it is to the south, and the borings put down south of Tátpali appear to indicate that it is very slight. But at one spot, at a tank almost due south of Egerpeta and north-west of Golagúdem, sandstone is seen dipping to the north-east at 60,° proving the existence either of faulting or of great local disturbance. From this place little, if anything, is seen to the westward as far as Gogúleáká. In a field close to Egerpeta some Tálchír shales were found, but none could be detected thence to the westward till about half a mile east of Ghútipár, where they are exposed along the boundary for a short distance, and are well seen in a small nalá, all in thick jungle.

The hills near Deorpalí consist entirely of grit or conglomerate, and no shale is seen in the section exposed in the river. It appears most probable that the rocks belong to the Kámthí group. Whether a fault, in continuation of the boundary south of Mádaváram, runs up the river, separating these rocks from those of Amraváram, is doubtful. Even if such be the case, it may be of older date than the Kámthís, which here, as near Lingálá, appear to be proved by their distribution to be quite unconformable to the Damúdas.

* Vágú, Telinga for stream, equivalent to Nadi in Hindustani.

Sandstone tract near Mádavâram.

The tract of sandstone on the right bank of the river opposite to that just described extends from near Mádavâram to Poláram, or rather more than four miles from east to west. Where broadest it is between two and three miles from north to south. The southern boundary is nearly straight, and although there is not, except in the south-east corner, much appearance of disturbance along it, it is difficult to believe that it is natural. The dip throughout is to the westward, and usually rather high, being seldom less than 10°, frequently 15°, 20°, or even 30°. Tálchírs occur in the extreme south-east corner; all the remaining area appears to be occupied by Damúdas.

The Tálchírs are only seen in a stream which runs into the Godávarí near Ráigomá; they are the usual fine silty shales and sandstones, and are vertical, or dip at high angles to the west and north-west. They were not seen between the two hills just north of this spot, the one of metamorphics, the other of Damúda grit and conglomerate.

The whole eastern boundary of the rocks north of these two hills is concealed by alluvium in the river, which here runs north and south; metamorphics are seen along the left bank. To the east of the alluvium is a low rise formed of conglomerate, extending north to the river east of Mádavâram and terminating on the south in the high hill just referred to, which lies west of the village of Kondapali. This hill has precipitous sides to the east and south, exposing a section of the conglomerates composing it.

In the small stream which runs into the Godávarí near Injáram, north of Kondapali, much conglomerate is seen, but no continuous section is exposed for any distance. Rocks are traced at intervals along the southern boundary of the field, and are usually conglomeratic. The hills near Poláram and a smaller rise south-east of it are of the same kind of rock. This of course is in favour of the southern boundary being natural, but it should be remembered that the conglomerates being harder, are more likely to be exposed than the softer rocks which may intervene between them. There is much lime along the southern boundary near the villages of Palchalkar and Gangáram, some compact limestone occurring north of the last named village, but it is apparently a superficial accumulation.

Throughout this sandstone tract, as a general rule, very little rock is seen; usually when any appears above the surface, as west of the tank south of Shirúveli, it is grit or conglomerate. But a tolerable, though by no means continuous, section is exposed in the bank of the Godávarí. Here also the eastern boundary is not seen, metamorphics are met with about half way across the river bed (here about a mile broad) opposite the village of Murmur, and at the salient angle of the river bank below Mádavâram there is horizontal conglomerate and grit, being the same beds as those forming the rise which bounds the sandstone tract on the east. The conglomeratic character appears to diminish rapidly to the westward, in which direction the beds for a short distance dip east, exposing about 100 feet of rocks, sandstone grit, and some argillaceous beds. The dip then changes to the westward just at the mouth of a small nalá, and grey or pale brown sandstone with occasional bands of grit or shale, all of typical Damúda characters, dip at a high and rapidly increasing angle to the westward. At the anticlinal opposite the mouth of the little nalá, a borehole was made to a depth of 193 feet 6 inches in order to prove rocks lower than any exposed on the section. It went through alternations of brown and white sandstones, with thick beds of dark shale containing two or three small and useless seams of coal, none of them exceeding 8 inches in thickness (see Records, 1871, p. 61).

At Mádavâram there is some crushing and, possibly, faulting, the sandstone being cut up by calcareous veins. A high dip, varying from 20° to 40°, continues along the river bank as far as Shirúveli, the beds being coarse or fine sandstones of varying hardness with occasional

shales. Near Shirúveli the dip becomes lower. In some clays just east of the village *Glossopteris*, *Pecopteris*, *Vertebraria*, and *Calamites* occur.

Thence to Damarcherla the dip is moderate, about 5° to 10°, and the rocks fairly seen on the whole. They are much the same as to the eastward, fine felspathic sandstone and fine clays predominating, with occasional hard massive bands of fine brown sandstone. At Damarcherla there is a little conglomerate and some hard ferruginous bands like those in the Kámthís.

About half a mile, or rather less, west of Damarcherla, the beds roll up sharply, and there may be a fault here. They soon roll over again and consist of coarse felspathic sandstones, generally pink coloured or ferruginous, and conglomerates, but associated with hard compact grey felspathic sandstones. These rocks continue to beyond Poláram, metamorphics appearing at the mouth of the stream west of the village.

Magnetic iron ore near Poláram.

Iron manufacture.

A small rising ground in the metamorphics south of Poláram contains large quantities of magnetic iron ore in laminæ with quartz. The ore has evidently been largely dug from this spot for small diggings are scattered over the ground. The iron ore shows very distinct polarity in its action on the needle. In a small village near this I found women making iron in a little furnace barely 2 feet high—a miniature of the Tálchír furnace—worked by small foot bellows about 1 foot in diameter. The furnace inside is only 6 inches in diameter at the base, 3 inches at the top. It is said by the people that two pieces of iron, each weighing $1\frac{1}{2}$ seer and valued at 4 annas, are made in a day.*

Sandstones near Púndigúl and Amravá-ram.

Sandstone again comes in on the right bank of the river close to the abandoned village site of Púndigúl. The actual junction of the two series is again concealed, but there can be little doubt of the boundary being natural. It runs to the southward into dense jungle, where its position is difficult to ascertain correctly on so imperfect a map; the rocks being very poorly seen.

Sandstones near Amravāram.

In the right bank of the Godávarí, from just above the base at Púndigúl to the village of Amraváram, a good section is exposed in which very few breaks occur. The general dip is west, varying in amount from about 7° to 12°. Towards the base yellowish-brown sandstone prevails, coarse and felspathic. Above this, to the north of the hill, there is much conglomerate, and thence to Amraváram sandstone again. No clay or shale is seen, much less coal, but some coarse impure ironstone occurs.

About the middle of the village† the section ends, and only scattered outcrops, concealed beneath the river except in the driest season, occur in the bank of the river above. Just above the mouth of the stream, which enters the river above the village, fragments of coal occur on the river's bank just below a conspicuous clump of green bushes; some sandstone occurs in the bushes, and a boring might be put down through it. Above this, again, but one small outcrop of rock is seen, nearly in front of Thondipálí, as far as Gúmpanápali just below Rágúdem. Even near Mondipák (nearly opposite Gagúbáká) only a few blocks of coarse sandstone are exposed. Near the river bank the country is an alluvial flat, and farther inland a sandy rise covered with thick jungle, amongst which a few scattered blocks of coarse sandstone and conglomerate may occasionally be seen.

* The people were of Lohar caste, *i. e.*, low caste Hindus. The Kois, who are Kolarians (though called Gonds by the Mussulmans of the country), are said to make iron with foot bellows in a hole in the ground without any furnace at all.

† This is placed too far east on the map, which is very inaccurate about here.

The nalá which runs into the Godávarí, east of Amraváram, exposes no rock for some distance from its mouth, and no good section is anywhere seen in it. Soft felspathic sandstones and, towards the base, conglomerates are met with in it here and there. Even less rock is seen in the large Machimangú nalá which runs past Kometlagúdem. Sandstone only appears in this in the form of a few blocks, exposed just below the junction of the two principal streams which unite to form it. The more westwardly of the two joining streams, however, only traverses metamorphics for a very short distance: above this Tálchírs are exposed, although there are none in the main stream a few hundred yards distant, where the metamorphics and Damúdas are seen within a few yards of each other. After about one quarter of a mile of Tálchírs, Damúdas or Kámthís (they are undistinguishable here) again come in dipping west south-west. There is a considerable quantity of coarse felspathic sandstone of various colours, mostly brown, or irregularly streaked, and hard ferruginous bands occur at intervals; occasionally clay is found in the sandstone. Conglomerate is not prevalent, but it is met here and there.

There is absolutely nothing about these beds by which they can be distinguished from Damúdas, but there can be but little doubt that the greater portion, if not all, belong to the Kámthís. From the general dip they must have overlapped the Amraváram beds. They appear softer than the rocks seen in the river's bank near Amraváram and Mádaváram, but this is not an important distinction.

The hills near Kometlagúdem are of open textured felspathic sandstone, usually white or pale brown in colour, with hard ferruginous bands. The sandstones on the hills in this neighbourhood have generally this somewhat open texture, which is not usually seen in ravine sections, and may be due to the washing out of the decomposed felspar from between the grains of quartz. The character of the sandstone is that of the Kámthí beds, but no typical Kámthí rocks occur, neither vitreous sandstone, nor the red and yellow compact shale, nor the fine micaceous variegated sandstone.

From these hills, others formed of similar sandstone stretch away to the southward, bordered to the east in the valley of the Machimangú stream by metamorphics, no Tálchírs intervening.

(To be continued).

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OF

INDIA.

VOL. V.

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THOMAS OLDHAM, LL.D., F.R.S.,

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1872. [February.

Annual Report of the Geological Survey of India, and of the Geological Museum, Calcutta, for the year 1871.

The close of the year calls for the usual annual summary of proceedings of the Geological Survey.

As regards the staff available during the twelve-months from the 1st of January to the 31st December 1871, we have been rather more fortunate during the past year than on other occasions. During a portion of that time, all the members of the Survey establishment were at work at the same time—a rare occurrence. Shortly after the year opened, Mr. Jos. W. Alexander was appointed an assistant in the room of Mr. Ormsby, whose death it was my duty to report in 1870. Mr. Alexander was engaged in office work for some months, and gave high promise of efficiency. After a few months, he was, however, nominated by the Hon'ble the Lieutenant-Governor of Bengal to the charge of the Maharajah of Durbungah and of his brother (minors). His place was fortunately supplied without much delay by the appointment of Mr. James Willson, A. B., whose university course had been marked by the highest honours, and who had for some time been engaged successfully as Professor of Mathematics in this country. He had given special attention to the study of Physics, Geology and Mineralogy, and had obtained honors in these subjects at his final examination in Trinity College, Dublin. He has been actively engaged since his nomination in October.

These repeated changes, as frequently noticed, give rise to delay, complications and difficulties, which very seriously impede the progress of the survey. It has been recommended as the best means of preventing, so far as practicable, this injurious result, that two or three supernumerary assistants should be appointed who would become absorbed into the general staff as vacancies occurred, and who would meanwhile have acquired a sufficient intimacy with local geology, and with the modes of enquiry to enable them to be at once effective and useful. The working staff would thus be maintained at its proper strength and an equable progress would be secured. At present, every new assistant is comparatively useless for one whole working season, until he has become acquainted with what has been done, and can thus take his place with the others in extending this knowledge.

Mr. Medlicott, who, as stated in last report, had commenced the detailed examination of the country near Mohpani coal-field, and the Puchmurri hills, on the south of the Nerbudda valley, using for the purpose of recording his observations the maps of the Topographical Survey, just issued, was enabled to get over a considerable area. As noted on a

former occasion, when this important district was first visited by the Geological Survey in 1856-57, no maps of it existed, and to give even an approximate idea of the structure, it was necessary to construct a sketch map as our work progressed. This, of course, had no pretensions to great accuracy, and it was therefore important to take advantage of the publication of the regular survey maps at the earliest date. Towards the close of the season, Mr. Medlicott, I regret to say, suffered from a very severe attack of fever which incapacitated him for work. Hoping that a little rest and change of air would restore him to health, he obtained three months' privilege leave and proceeded to England, but the attack proved so severe and continued that he was obliged to obtain an extension of leave on medical certificate. Finding himself quite well again, he has returned before his leave expired, and has taken up the continuation of his old work on which he is now engaged. It is hoped that he may have no return of the attack. He resumed work at the commencement of December.

Mr. W. T. Blanford, who had at the opening of the season proceeded to the Godavery river to report upon the various places where coal had been said to occur in the vicinity of the great works for the improvement of the Godavery at Dumagudium, very successfully completed the careful mapping of the coal-bearing rocks within the British territory, and carried the lines of boundary into the country of His Highness the Nizam on the opposite side of the river. Two sets of boring-rods had been sent out from England for this district, and these were placed under the immediate charge of Mr. J. Vanstavern, C. E., Executive Engineer at the Godavery works. Previously to the arrival of these tools, Mr. Vanstavern had been carrying out a series of short borings with some small tools at his disposal, but immediately on receipt of the others, he commenced a systematic examination of the entire area of coal rocks on the British side of the river, acting strictly in compliance with Mr. Blanford's suggestions. Mr. Heppel was also moved down from Chanda district, and for a short time superintended the actual borings. After his departure, and up to the present time, Mr. Vanstavern has with much skill, intelligence and system carried out the series of borings agreed upon, and there only remain now one or two still required to give a very complete insight into the structure of the area in question. It is unnecessary here to enter into details, as Mr. Blanford's results have been already published. Unfortunately there is little prospect here of any but a very limited supply of poor coal. The area of the rocks which occurs in British territory in this vicinity is very small, and the beds of coal which occur are most extremely irregular and thin. Mr. Blanford's estimate of 12,000 tons may be added to in consequence of more recent borings, but at best the supply is limited. And the larger portion of the coal must be sought for on the opposite bank of the river in the territories of His Highness the Nizam.

One of the first matters to which Mr. Blanford directed his attention on arrival at Dumagudium was to take advantage of the accurate local knowledge of the countries they inhabit, which is always possessed by the wilder tribes inhabiting the jungles and more inaccessible portions of the districts, by a well directed distribution of small fragments of coal over all the country, thus showing to the people actually what it was, for the discovery of which a liberal reward had been offered by the Government of the country. The success of this plan was not long after attested by the report to the local authority of the existence of thick beds of coal in the valley of a nullah not very far from Pakhall, in the vicinity of Warungul. There would seem to be here a thick bed of coal well exposed, said to be dipping at the high angle of 45°. The country around is all jungle, at present frequented by wild elephants, but it could be easily opened out. I have no doubt that other similar reports of coal will be brought in from time to time.

Mr. Blanford later in the season carried out a general mapping of the extent of the sandstone area in this part of the Nizam's dominions, and southward into Madras Presidency, where it stretches down to within about eight miles of Ellore. All these rocks as seen at surface appear to belong to the group which occurs over the true coal-bearing rocks. The country is very widely covered by jungle and poor forest, and is in many places quite inaccessible for close or detailed examination. But, so far as practicable, a knowledge of its structure will be obtained during the present year by Mr. King, who has been placed there for this purpose.

Mr. Blanford completed a long season in this very unhealthy country; but not, I regret to say, without suffering. He was very unwell afterwards in Calcutta, but was able to take the field in Sind at the beginning of the present season. On his way thither, he devoted some time to the examination of the neighbourhood of Bombay, where the Municipal Commissioner had sought the advice of a Geologist with reference to a proposed plan of conveying water to the city through tunnels in the solid rock, which it was supposed would prove much cheaper than the laying down of iron pipes.

Since Mr. Blanford's arrival in Sind, he has been deputed to accompany the Boundary Commission under Sir F. Goldsmid in its visit to Seistan, &c., a trip from which I confidently anticipate that much valuable information regarding a country almost entirely unknown will be derived. It is a duty also for which Mr. Blanford's wide acquaintance with Natural History in general as well as Geology peculiarly qualifies him. He has made most excellent use of the brief delay which occurred before starting, and has been able to visit many places of interest in the Persian Gulf and also on the Arabian Coast.

Mr. W. King, Deputy Superintendent for Madras, on his return from furlough, commenced his field examination from the Toongabudra river, and examined the country lying on either side of the Madras and Bombay railway up to the boundary of the great area of trap rocks which cover such an immense space in the Deccan. The main object, as stated before, was to carry out here an investigation of the several rocks which occur between this vast thickness of overlying trappean rocks above and the even more widely spread base of the underlying gneiss and other metamorphic rocks below. Joining on, therefore, to the south-west with the lines already fixed by Mr. Foote as noticed in last report, Mr. King advanced to the north-east, and was able to get over about 1,400 square miles of area up to Goolburga. Towards the latter part of the season Mr. King was attacked with fever, and other symptoms, and was driven into Bombay for medical advice. On getting better, he quickly returned to his work; but the season was then so far advanced that much further progress was impracticable.

The rocks met with were (1st) the crystalline metamorphics, consisting chiefly of granitoid gneiss, quartzo-felspathic in composition, with little foliation, where seen with a northerly strike and at low angles. This gneiss is much traversed by small granite veins (binary,) lying to a large extent in the lines of dip. Occasional bands of hornblendic gneiss also occur. The hilly and rugged parts are also frequently studded over with large bosses and tors. The surface is generally flat and covered up by black cotton soil and alluvial deposits.

Overlying the gneiss in the valley of the Bheema is a series of limestones, sub-metamorphic in texture and bearing a strong general resemblance to the Karnúl rocks. This may be provisionally called the Bheema group. It consists in descending order of—Red purple and chocolate coloured calcareous shales, flags and thin-bedded earthy-grey limestones; thicker bedded earthy and sub-crystalline limestones. There is locally a great lenticular patch of quartzitic, sandy and conglomeratic beds. There are also, of course, many local variations in the groups from the general character given above. The most remarkable of these is a series of brecciated beds, in which the materials composing the layers have been separated into numerous

sharply angular pieces, and recemented by a material of precisely the same general character as the mass. These are exactly like similar beds described in the Karnúl and Kadapah formations. Generally, the lie of these Bheema beds is quite flat, or with a gentle dip to the north-west. The different groups noticed above do not appear to be unconformable, but the newer overlap the older to a considerable extent. This is the case also with the trappean beds which come over and rest upon the Bheema rocks. Where in contact, only slight alteration has been produced in the underlying beds by the overflow of the traps; purple shales become of a bright red colour, and weather with a soft velvety powdery surface, &c.

Of the traps themselves, there is only a very limited thickness near the boundary. The series is made up of several thin flows of various kinds, and of different degrees of compactness and hardness. The uppermost flow is generally decomposed into a form of lateritic rock.

Mr. King has at the commencement of the present working season carried on these boundaries a little further to the north-east, but was obliged to hurry on to take up the examination of the Godavery area to which Mr. Blanford was unable to return. In addition to this field work he has also supplied the Director of Revenue Settlements, Madras, with notes on the geology of the Cuddapah and Nellore districts.

Mr. Bruce Foote continued the examination of the similar rocks to the south-west joining on to the limits of last year's exploration. It was hoped that he would have been able to complete the country up to the western ghats, but the boundaries proved so much more intricate and complicated than was anticipated, that this was impracticable. Mr. Foote's close examination of the country was rewarded towards the end of the season by the very interesting and important discovery of the fossilized remains of a *Rhinoceros* in the regur or black cotton soil. These have since been worked out with great care by Mr. Foote, and will be hereafter described.

Mr. W. L. Willson has continued the examination of the southern portion of the Jhansi district, and of Lullutpur to the south, and the native states of Tehree, &c., to the east. Over all this country the same remarkable series of trappean dykes and quartz reefs, already noticed as occurring in the adjoining districts, can be seen, running up to the Par sandstone scarp south of Gwalior to the north-west, and to the very bases of the Vindhyan and Bijawur rocks in the south-east. In no case, however, do these dykes penetrate either of these formations. They occur, apparently more numerously than elsewhere, from a few miles north-east of Jhansi to the Vindhyan scarp on the south-east; their range being chiefly from north-20° west to north-west. There is a tendency to a more easterly strike, as you pass to the north-east towards the Dessaun river and Nowgong, while along the Dessaun a very few occur, which head north, or a little west of north. The dykes frequently divide and form loops. Many of them are of considerable size, and a few can be traced for many miles in nearly right lines. They are, whatever their actual age may be geologically, undoubtedly subsequent to the 'quartz reefs,' through which they are seen to pass, and portions of which they show imbedded in the mass of trappean matter along the edges of the dyke.

Some curious outliers of the infra-trappean limestone were noticed in the southern part of Lullutpur well out on the general flat composed of the crystalline rocks and covered by the ordinary Malwa and Deccan trap rocks; these are of the usual earthy and cherty light coloured calcareous rocks, in places worked for lime to whitewash the houses with. North of Jacklone the base of the series, as elsewhere in Saugor, is formed of pebbles of sandstone in which numerous fragments of chert and limestone occur. When the soft matrix is washed out the beds appear to consist only of these pebbles, occasionally some feet in thickness. Black soil occurs in all these localities over the kunkury clay, which forms beds of considerable thickness, 30 to 50 feet. Mr. Willson also notices a remarkable local development of

black soil. "In very many places, when a large dyke is traceable through a valley, with ridges of gneissose rocks on either side, it frequently forms a marked lane of black clay up to the base rocks bounding it. And the dyke may often be traced across alluvial ground by this lane-shaped band of black clay, although no rock is visible." Another fact in the physical configuration of the country arises from the resistance to decomposition of these trap dykes, which, therefore, very frequently occur along the top of the minor watersheds, where also most of the villages are placed.

During the present season, Mr. Willson continues this examination to the east, completing the northern portion of Dumoh district, for which no maps were available in former years.

Mr. Fred. Mallet had been deputed towards the close of last year, when returning from Europe, to visit and examine the vicinity of Aden, with especial reference to the possibility of obtaining a good supply of pure water for the inhabitants of that important station. The results of this examination were published immediately on his return. He showed that there was an abundance of water nearer to the foot of the hills a short distance from Aden, but that this became absorbed in the sands that intervened between these streams and the sea; in other words, that there was an abundance of good water, but that artificial means of conducting it into Aden would be requisite. There seemed nowhere such a structure as would justify the expectation of procuring water by wells sunk on the artesian principle.

Immediately on his return to India from this duty, Mr. Mallet was despatched to complete the geological examination of the southern part of the Mirzapúr district which had been left unfinished. This would carry our knowledge of the geological structure of that country southwards to the long known coal-pits of Kota, which were to be examined in greater detail so soon as the maps of the adjoining country were available. This duty Mr. Mallet effectively performed. During the recess he has been engaged in working up his maps, &c., and in a careful examination of some interesting minerals he met with in that district in connection with extensive masses of Corundum, and of which a brief account is given in the present number of the "Records of the Survey."

To Mr. Mallet I also entrusted the entire remodelling of our collection of minerals. When first the Museum was opened, the best series which our collection then afforded was brought together, and was arranged by Mr. H. F. Blanford for exhibition. This was unfortunately a very incomplete and poor series, but such as it was it proved useful. During subsequent years, this collection has been steadily kept in view, as opportunity offered of acquiring additional specimens. And as a large number of additions had been brought together by donation, by occasional purchase, and by exchange, it was determined to have the whole series remodelled. The collections had been arranged in accordance with the fourth edition of Dana's system of Mineralogy (1854), but was now brought into agreement with the last or fifth edition, 1869. Up to last year the arranged collection represented 224 species by 1,460 specimens. It now represents 358 species by 2,239 specimens. The number of specimens used to illustrate each species remains therefore about the same (6 to 7), but the actual number has been increased by 779. But as, in addition to this increase in number, many inferior specimens have been eliminated and better ones introduced in their stead, and a few which had been misnamed removed, the actual number of *new* specimens added has considerably exceeded this addition to the total number. These new specimens have been selected from the various collections stored from time to time in the Museum; from others purchased from Professors Klipstein, Krantz, &c., and from others presented by various persons or obtained in exchange, as well as from those collected in various parts of the country by the officers of the Survey.

Mr. Mallet himself had also brought back with him from Europe some very interesting and valuable additions, all of which have been embodied in the general series.

It is at all times a difficult and costly task to form a really valuable series of minerals. Many varieties can be obtained only at rare intervals and under favorable circumstances, and excepting by the purchase of some good collection, the growth of many years of constant attention, it would be impracticable now to produce any extensive and really fine collection of minerals within a limited time. The object, therefore, has been to render our series as practically useful as was possible, leaving the obtaining of handsome or showy specimens of various species to such future opportunities as may occur. The general value of the series may be gathered from a summary of the number of representatives of each group into which it is divided. We have of—

	Species.	*Specimens.*
Native Elements	14	106
Sulphides, Arsenides, &c.	48	298
Chlorides	6	16
Fluorides	6	56
Oxides	39	523
Anhydrous Silicates	75	445
Hydrous Silicates	65	315
Tantalates, Columbates	5	11
Phosphates, Arseniates, &c.	33	103
Borates	5	10
Tungstates, Molybdates, &c.	7	23
Sulphates, Chromates, &c.	22	93
Carbonates	20	198
Oxalates	2	2
Hydrocarbon Compounds	11	40
	358	2,239

The most important additions have been native Gold, native Platinum, and Platinum metals; native Sulphur from Ladak; very fine crystals of Galena; Cinnabar, Nickel and Cobalt ores; Bournonite; Tetrahedrite; soluble Chlorides from Stassfurt, Fluorides from Greenland; Cuprite from Cornwall; Hæmatite; Spinel; Magnetite; Rutile; Pyrolusite; Diaspore; Manganite; Limonite; Brucite; Psilomelane; Wad; some remarkably fine specimens of quartz and opal; Wollastonite from Auerbach; varieties of Augite and Hornblende; Tachyllite; Beryls from Donegal; Emerald from Siberia; Olivine; many very fine additions to the Mica and Felspar series; Tourmaline; Kyanite; Sphene; Dioptase; a few additions to the Zeolite series; Serpentines from the Lizard; Margarite from North America; Pyromorphite; Lazulite; Borates, especially Boracite in beautiful crystals; Tungstates; Molybdates; some fine crystals of Crocoisite; soluble sulphates from Stassfurt; Siderite; Cerusite; Niellite and other organic compounds, in addition to many rare minerals, which were unrepresented in the collection previously.

Mr. Mallet has carried out this re-arrangement with great zeal and success. He had slight aid for a time from Mr. Alexander, but on his departure was alone in the work. And the ability with which it has been done under excessive difficulty as to space, and other important inconveniences, and in rooms specially badly lighted, have borne ample testimony to the many advantages of study in Europe, which Mr. Mallet had been liberally allowed to reap during three months' time in addition to his furlough. The cost of this indulgence has been much more than repaid to the survey, not only by the additional knowledge so earnestly acquired by Mr. Mallet, but also by the valuable series he brought back with him.

In addition to this labour, Mr. Mallet undertook the duties of Curator, during the temporary absence of Mr. Tween, for three months' privilege leave.

Mr. Mallet has this season again taken up the examination of the Kota coal-field, extending as it does both into Rewa and Chota Nagpore.

At the commencement of the year (1871), as stated in the Report of 1870, Mr. Hughes was actively engaged in the investigation of the Wurdha river coal-fields. During the early portion of the season, his time was much occupied in meeting the district officers during their visits to the field, and in pointing out to them how much had been ascertained regarding the coal. These interruptions to his regular work most seriously interfered with his progress, and by necessitating frequent long and forced marches to and fro, without any sufficient convenience for such rapid moving, the cost of which is such as the limited allowances of the Geological Survey do not meet, they also resulted in his being laid up by an injury to one of his feet, which for some time entirely prevented his moving about at all. He remained, however, on the ground, and continued to give advice as to the borings. As soon as able, he resumed his work, but at the close of the season he was obliged to proceed home on medical certificate.

Late in the season (May) he crossed into His Highness the Nizam's territories, and pointed out to Mr. Whyte, who had been sent by the Nizam's Government to put down trial borings in the country opposite Ballarpur, the structure of the rocks, and suitable places to work, for which aid Mr. Whyte expressed his obligation, and I am informed that the result has been the proving the existence there of more than fifty feet in thickness of coal.

During the season, the various borings carried out on both sides of the river have entirely confirmed the conclusion already arrived at with respect to this field, and have established conclusively upon what a very irregular surface the upper rocks have been deposited. The eastern boundary of these rocks was examined for a considerable distance, and they were found to be faulted against the gneiss, as far south as Sitarampett, or nearly to Moharli; here, however, the fault at the surface passes through the Kamthi rocks themselves, bringing into contact different beds of the same series. South of Moharli again the gneiss and sandstone are in contact along the boundary fault. The occurrence also of a small inlier of the Talchír rocks between Walwut and Sinála adds a convincing fact to the other evidence as to the irregular thickness of the upper (Kamthi) series, and shows the necessity for actual trials before attempting to assert definitely the depth at which, or the points where, coal may be found. The general structure of the whole field, namely, a wide anticlinal, largely denuded at the top of the curve as pointed out (by Mr. W. Blanford,) on the first examination of the area, coupled with the many instances in which the Vindhyan rocks below the coal occur in isolated and detached patches either at the surface, or at small depths below it, places it beyond a question, that this central portion of the field is one in which the flooring of the older rocks comes very near to the surface, and so irregularly that the coal, where found, will only be in small and discontinuous basins. For any large and continuous areas, we must go beyond this portion. To the west, the existence of the coal has been fully proved over a long line of country in East Berar. To the east there is no reason to assume its absence, but its occurrence has not been proved as yet.

Wurrora, where a coal-pit has been commenced, is unfortunately not, as stated, on the east scarp of the anticlinal, but a considerable distance from it, although the coal extends over a sufficient area to yield a good supply for some time.

From a knowledge of these facts, and a general consideration of the lie of the ground, I was compelled during the year, on the question being referred to me, as to 'what action should be

taken in the matter' regarding the proposed line of railway to connect these coal-fields with the Bombay and Nagpore railway, to point out the facts, and to urge strongly, that if the object in view were to obtain the coal cheaply, there could be little question, that a line direct to the Woon district of East Berar would be both shorter and cheaper, and would at the same time be more effective in tapping the largest and best cotton-growing districts of the country. This line would have to cross only one large stream, the Wurdah, while the other line, as proposed to Wurrora, would have to cross four or five, of which even one, taken alone, would be heavier than the Wurdah, as shown by the estimates. I have been informed, though not officially, that after a consultation between the Chief Commissioner of the Central Provinces and the Commissioner of East Berar, this alteration in the line proposed has been recommended. If carried out, it will undoubtedly give an easy access to a very large supply of coal of such quality as occurs in this field. All that has been found is of poor quality, breaks down very rapidly on exposure and drying, and is therefore wasteful; nor will it bear very heavy draft in the fires, but with properly adjusted fire-bars and frequent care it can be used with success. The coal from near Sastu, in the Nizam's dominions, is the most durable yet raised in these fields.

In connection with this field, it is much to be regretted that some trial borings were not during the season devoted to proving the eastern slope of the anticlinal referred to above. A few well selected borings would have settled the point as to the existence of coal. As I have already said there is no reason to assume its absence, but it has not as yet been proved to be present anywhere along this line. A trial boring was put down to the east of the town of Chanda at an early date, but this having reached a depth at which the progress weekly with hand-boring was only a few inches, was stopped on the arrival of a steam-boring machine. This was at once put to work a little further to the dip, but the ground proved so soft that tubing was required, which was not available at the moment. The steam-borer was then moved to Wurrora, and has been kept there since. And no further attempt has been made to prove the coal. There is most probably a large area over which it will be found, and possibly at very workable depths. Any part of this eastern scarp of the anticlinal will, however, be much more distant from the existing lines of railway than other sources of coal, and will, therefore, be more looked to in the future than at present. There is also a very large area of His Highness the Nizam's dominions, under which workable coal will be found, and which will at some future time prove very valuable. The occurrence of nearly 50 feet of coal, as proved at Sastu by Mr. Whyte working on behalf of the Nizam's Government, is only an instance. When examining the neighbourhood of Ballarpur, in the commencement of 1870, on the opposite bank, it was stated that the larger part of the coal would be found in the right bank of the Wurdah in the Nizam's dominions. And these sinkings have quite confirmed the statement.

Mr. Hughes is still absent on leave.

Mr. Fedden was engaged in continuing his examination of the trappean rocks overlying the coal-bearing series to the west, and in clearing up one or two doubtful points as to their boundary, &c. In the jungly country of Edulabad and to the east of that town between it and the Wurdah, he suffered from repeated attacks of fever, which at last drove him from the place; and under medical advice, he proceeded somewhat earlier than customary to the hills. He has resumed his work in better strength this season, and as from the small amount of rainfall in these districts the state of the country is more favourable for work than usual, it is hoped he will be able to effect good progress.

Mr. Hacket during this season completed the district of Jubbulpur, of which he had in the previous year commenced the examination. The southern, south-eastern and south-

western portions having been completed last season, the remainder has come under observation now. It was hoped also that the small district of Bijooragooghur, now attached to and forming a portion of Jubbulpur, would have been completed also, but Mr. Hacket was laid up towards the close of the season by several slight attacks of fever and its consequences, which prevented this.

The (Bijawur) series extends in a north-east and south-west direction across the central portion of the district. At the north-eastern end, on the water shed between the Nerbudda and the Mahanuddy rivers, they occupy nearly the entire surface, which intervenes between the Jubbulpur beds and the trap area to the south, and the Vindhyan rocks to the north. Here they form a considerable range of hills, the Bhitree hills, but towards the south-west in the Nerbudda valley, the section is less perfectly seen, and the rocks of the series are only seen in a few large hills isolated by the alluvium. West of Jubbulpur, with the exception of a fringe of rocks cropping out from under the trap on the south side of the valley, and of a few small hills on the northern side, the series is covered by the Nerbudda alluvium. The Bijawur series includes a great variety of rocks, of which the principal are slate, micaceous quartzites, limestone, ribboned jasper rocks, highly ferruginous and banded silicious rocks, micaceous schists, and igneous trappean rocks, both contemporaneous and intrusive. Cleavage abounds especially in the lower rocks, and often obliterates the dip; the cleavage heading east 15° to 20° north and underlying to the south at 60°. The whole series, notwithstanding very numerous local contortions, may be described as forming a shallow synclinal, the lowest group cropping out on the northern and southern sides and the higher group being best seen in the centre of the area. Four groups may be defined, though they pass gradually into each other. These in descending order are (1) the Chunderdeep group, called after the station of that name, and consisting of mica schists and limestones; (2) the Lora group, called after the Lora hills near Sehora, consisting of ribboned schists, in places highly ferruginous; (3) the Bhitree group, called after the Bhitree hills at the east end of the district, consists in places of ribboned jasper, in places of quartzites with but little of this structure, and sometimes of schists, somewhat conglomeratic; and (4) the Mujhowlee group, well seen near the town of that name, consisting of slates, quartzites, and limestone. Although these are the lowest rocks seen, they do not constitute the base of the series.

It would be of little use to enter into detailed description of these rocks without a geological map, and we shall therefore confine our observation to a very few points only. There are not many trap dykes seen, although it is possible that many exist which are concealed. Where the rocks are clearly exposed, as at the Marble rocks, several occur, offering peculiar varieties. Of the economic products of the district the iron ores are the most valuable. They occur entirely in the Lora group (with the exception of a very small quantity obtained from the laterite of Bijooragooghur). The most important mines are at Joulee; others are at Gogra, &c.: from Joulee alone fifty loaded buffaloes, each carrying about 3 maunds of the ore, are said to be despatched daily. The ore is a rich micaceous iron with hæmatite. It yielded, on assay, 68·5 per cent. of iron. Mr. Olpherts, the resident engineer at Kutnee on the Jubbulpur line of railway, has leased these Joulee mines from Government, and has succeeded in bringing the hæmatite which occurs there into use as a paint-stuff. For this, on outdoor work and especially on iron, it is admirably adapted. He has erected on the Kutnee river, near Moorwarra, three or four little native constructed water-wheels, which turn grindstones about three feet in diameter, made of the Réwah sandstone. These grind the ore to an impalpable powder, after which it is dried and packed in cases. It sells retail for about £13 per ton. The excavations at Pullee are nearly 100

yards long by about 30 yards wide and 50 feet deep. There are also some old workings some quarter of a mile distant, where large excavations have formerly been made. The mines at Mungela, and at Agorea in the Mujgoan hills, and also in the hills west of the Marble rocks, are all situated on the same geological horizon, and the deposit of iron ore would appear to be very constant, and to offer a practically unlimited supply of the very best quality of ore. Small traces of copper and lead have also been found, but nowhere in quantity which appeared to offer any prospect of working them to profit.

Mr. Ball, who, as stated in last year's report, had proceeded to the south of Chota Nagpore and Sirgujah, completed last season a most admirable and largely extended reconnoissance of a very extensive area. As stated then, there were gaps, for which no maps or surveys existed, so that detailed work was impracticable. But Mr. Ball has in a very satisfactory way obtained an approximate knowledge of the limitation of the various series of rocks, which will prove of the greatest service, when detailed examination can be taken up. And all this in a country where scarcely a road exists, and where it was essential to travel with the least possible amount of comfort. I am happy to be able to report that Mr. Ball has not suffered in health from his sojourn in these jungles, generally reputed very unhealthy. This season, Mr. Ball (taking with him Mr. James Willson, who, having only recently joined the survey, required initiation into the peculiarities of the various groups of rocks), has taken up the more detailed examination of the north-western extremity of the Chota Nagpore country, of which the survey maps have been published. Mr. Ball was absent for three months on privilege leave during the recess, a holiday which he had well earned.

In Burmah, Mr. Theobald was more especially engaged in the examination or rather re-examination of the Arakan range of the Yoma. The peculiar relations of the altered rocks seen towards the centre of that range with the unaltered nummulitic rocks which occur in the flanks, to which Mr. Theobald has directed attention in papers published in the Records of the Survey, were still on many points open to doubt and question, and to determine these questions, Mr. Theobald crossed the range in several places right from the low ground of the Irrawadi to the sea coast. By these traverses he has satisfied himself that, notwithstanding the remarkable alterations to which the rocks occurring along the axis of the range have been subjected, they belong to one and the same series as the undoubtedly nummulitic rocks seen on their flanks. Mr. Theobald also paid special attention to the brine springs of British Burmah, of which he has submitted a list, which will soon be given in the Records of the Survey. The great deficiency in detail and accuracy of the maps of British Burmah which we have to use, and the densely jungly nature of these less frequented portions of the country, must for generations render the close geological examination of the area quite impracticable, and all that can be looked for is such a general sketch of the geological structure as will give a tolerably accurate idea of the relations of the several rocks.

Mr. Wynne, who during the preceding year had completed the examination of the eastern portion of the salt range in the Punjab, worked out the western part of the same area in considerable detail, and is now engaged in the country lying to the north of this range, and extending up to Attock, Hossein Abdal, &c. The strangely disturbed condition in which the rocks of the salt range are found, due not only to distinct faulting and disturbance on a large scale, but also to almost countless slips of enormous size along the bold scarp to the south,—resulting in a complicated arrangement of the several rocks, so intricate that it would be impracticable to make it intelligible without careful plans and sections—rendered it perfectly essential that the greatest care should be devoted to the proper

investigation of the contained organic remains on the spot by a competent Palæontologist, and I have, therefore, taken advantage of Dr. W. Waagen's having joined the survey, and have entrusted to him a full examination of the relations and mode of occurrence of the fossils of this salt range, and I have no doubt that the results will prove highly valuable. Dr. Waagen, as will be seen from the coming number of the Records of the Survey, has already been able to throw much light in this way on the puzzling sections seen near Rawul Pindee.

Mr. Wynne's health was not at all as good as could be wished, but his zeal and earnest attention enabled him notwithstanding to work out the area visited with an amount of care and detail which is highly creditable.

I have also taken advantage of the well advanced state of the descriptions and plates of fossils to enable Dr. Stoliczka, the Palæontologist of the Survey, to visit and go over the curiously interesting sections of the district of Cutch. He proceeded thither in November, and is much indebted to His Highness the Rao and all the local officers for the most friendly aid which will enable him to see more in the short time he can devote to the work than he otherwise would have done. Valuable results have been already attained, but these will be better discussed after the examination has been completed. The entire series of fossils will prove most interesting and valuable; and Dr. Stoliczka's untiring zeal and energy will enable him to unravel, by actual examination on the spot, some of the doubtful questions as to the distribution of these fossils in the several beds and other points of high geological interest.

Mr. M. Fryar has been, during the whole year, detached on work not connected with the Geological Survey.

PUBLICATIONS.—The punctual issue of the RECORDS OF THE GEOLOGICAL SURVEY has been steadily maintained during the year. And I believe I am justified in stating that this series giving early knowledge of important facts is steadily becoming more appreciated. The numbers for the past year contain the Annual Report of the Geological Survey and Museum, and the usual quarterly lists of the additions to the Library. In addition to these, are details of the explorations for coal in the Godávarí valley, and descriptions of the accompanying rocks by Mr. W. T. Blanford: a general sketch of the geology of the Central Provinces; on the structure of the Konkan: Geology of Burmah; the Raigurh and Hengir coal-field; reported discoveries of coal in the Madras Presidency, and other papers, all largely increasing the knowledge of the Geology of India, and thus gradually building up the materials which will shortly enable a general geological map of the country to be prepared.

Of the PALÆONTOLOGIA INDICA, we have issued not only the four fasciculi due for the twelve months past, up to October 1871, but have also issued in anticipation the entire volume due for this year 1872, up to October. The great risks and uncertainties attending the execution of careful chalk drawings on stone in this climate have compelled me to anticipate our work in this respect as much as possible. From several years of trial, I found that it was only possible to be *certain* of our publication of these fossil plates being punctually maintained with our very limited staff, when we were able to keep in advance of the issue by nearly twelve months' work. We have therefore been gradually and by great exertions gaining on the issue or publication, until this year I was enabled to publish five fasciculi in one part of the description of the cretaceous bivalve fossils of Southern India. This completes the monograph of this class, and forms the third large volume of plates and

descriptions of that splendid series of fossils, the finest probably ever obtained from one limited district. The Pelecypoda have been treated with the same fulness of detail as the other groups, and the volume will be found to constitute a general treatise on the classification and relations of the fossil and recent bivalves generally, as well as a detailed description of the specific forms noticed in Southern India. This volume bears stronger testimony than any words of mine could to the ability and unceasing zeal of our Palæontologist, Dr. F. Stoliczka.

The next group to be taken up, the Brachiopoda, are all arranged for the drawings and plates, and the MSS. descriptions have been completed.

In addition to the completion of this volume of the cretaceous fossils, a fasciculus has been published descriptive of some peculiar crabs found fossil in the tertiary rocks of Sind and Cutch, also prepared by Dr. F. Stoliczka.

Almost immediately on Dr. W. Waagen's joining the Survey last year, the entire series of the Cephalopod fossils, collected in Kutch, was placed in his hands for careful examination and description. For this Dr. Waagen was singularly well qualified by his intimate and accurate knowledge of the jurassic rocks of Europe, and by his previous studies in this special family of organic remains. The result has fully justified our well grounded expectations. The last number of the Records of the Survey contained a brief abstract of his researches. These are such as cannot fail to prove of the highest importance in their bearing on Indian Geology, and brief as this mere abstract is, it is certainly one of the most valuable contributions yet made to Indian Palæontology. Not less than about 80 species of Ammonites alone have been recognized, of which 73 have been procured in sufficient preservation to be specifically described. Of these 73, 37 are old and well known species, and 36 are now for the first time described. Of all these, Dr. Waagen completed the detailed descriptions and careful drawings before going to the field. These drawings are now being lithographed.

The rich collections of fossils from Indian rocks (although as a whole the greater part of the country is singularly barren of any organic remains) which have been so rapidly accumulated are now being so expeditiously and systematically examined that the publication of them is limited only by the very small sum at our disposal for such purposes. The present rate of issue of the Palæontologia Indica could be with ease doubled if funds were available.

Of the MEMOIRS of the Geological Survey two volumes are nearly ready, but have been unavoidably delayed by accidental injuries to lithographs, so that they could not be published before the close of the year.

MAPS.—Sanction having been given to the publication of the larger scale maps which, whenever available, are always used in our field examination, arrangements have been in progress for carrying out this system. It has been necessary to make several trials before finally adopting any one plan, inasmuch as it is essential that all should be published on an uniform system, of colouring, of arrangement of maps, &c., &c. Draughtsmen had also to be trained to the work, differing essentially as it does from ordinary mapping work. These preliminary and tentative proceedings will now soon be brought to a close, and I expect that a short time will see the whole in good working order. A similar series of preliminary trials has been found essential in the lithographing of the maps for final colouring. In these, we are greatly indebted to the friendly interest which Captain Murray, of the Surveyor

General's Department, has evinced in the matter. And I doubt not that a short time will now suffice to bring the system into operation, after full prevision, so as to prevent their being any interruption afterwards.

Geological sketches of several districts have been furnished to local officers for use in gazetteers. Accounts of Bombay generally, of the North-Western Provinces, of Kerowli, have thus been supplied.

LIBRARY.—During the twelve-months one thousand and sixty-eight volumes or part of volumes have been added to the Library of the Geological Survey. Of this number about one-half, namely, 529, have been presented, and 539 have been purchased. A complete list of these accessions has been given in the successive numbers of the RECORDS. I append here a summary list of those Societies, Institutions, &c., from which presentations have been received during the last year. Recently established rules for the purchase of books, by which the purchase of any book in this country, however urgently required, has been strictly forbidden, and the establishment of an agency in London, which, however good for the provision of ordinary English books, never has had such connection with the foreign scientific societies, and such knowledge of the publication of scientific works, as would enable it satisfactorily to fulfil the duties of an agent for a purely scientific establishment such as the Geological Survey Library, will most seriously delay, obstruct, and impede the successful formation of what has ever been our great want here—a good Geological Library. The delays alone will necessarily throw back our information more than half a year. Books delivered for transmission to our library in May last arrived in middle of November, those sent to India Office in July were delivered in Calcutta in middle of December. In this case the cost of transmission direct by post would have been less than the cost of the cumbrous and needless packing in boxes of wood and tin. In scientific enquiries and researches it is essential that we should have rapid and ready access to the latest publications, and delays of this kind, therefore, most seriously diminish the utility and interest of our labours.

MUSEUM.—As frequently stated, we can only maintain our collections in order by removing one series so as to make room for the examination of another, and so gradually, but with great inconvenience, bring them all into arrangement. I have already stated that during the year our mineral collection has been overhauled and entirely remodelled. This could only be done by removing from the cases a collection of rocks. This difficulty will, I fear, continue in full force until the collections have been placed in the new building intended for their reception, when space sufficient for their exhibition and careful comparison will be available. Steady progress is, however, being made in the arrangement of the large collections, and in the sorting them, so as to form, when space is procurable, duplicate series for exchange or presentation.

An index map is appended showing approximately the present state of progress of the field work of the Survey.

The various collections are in as good order and safe keeping as the limited accommodation at our command will permit.

T. OLDHAM,

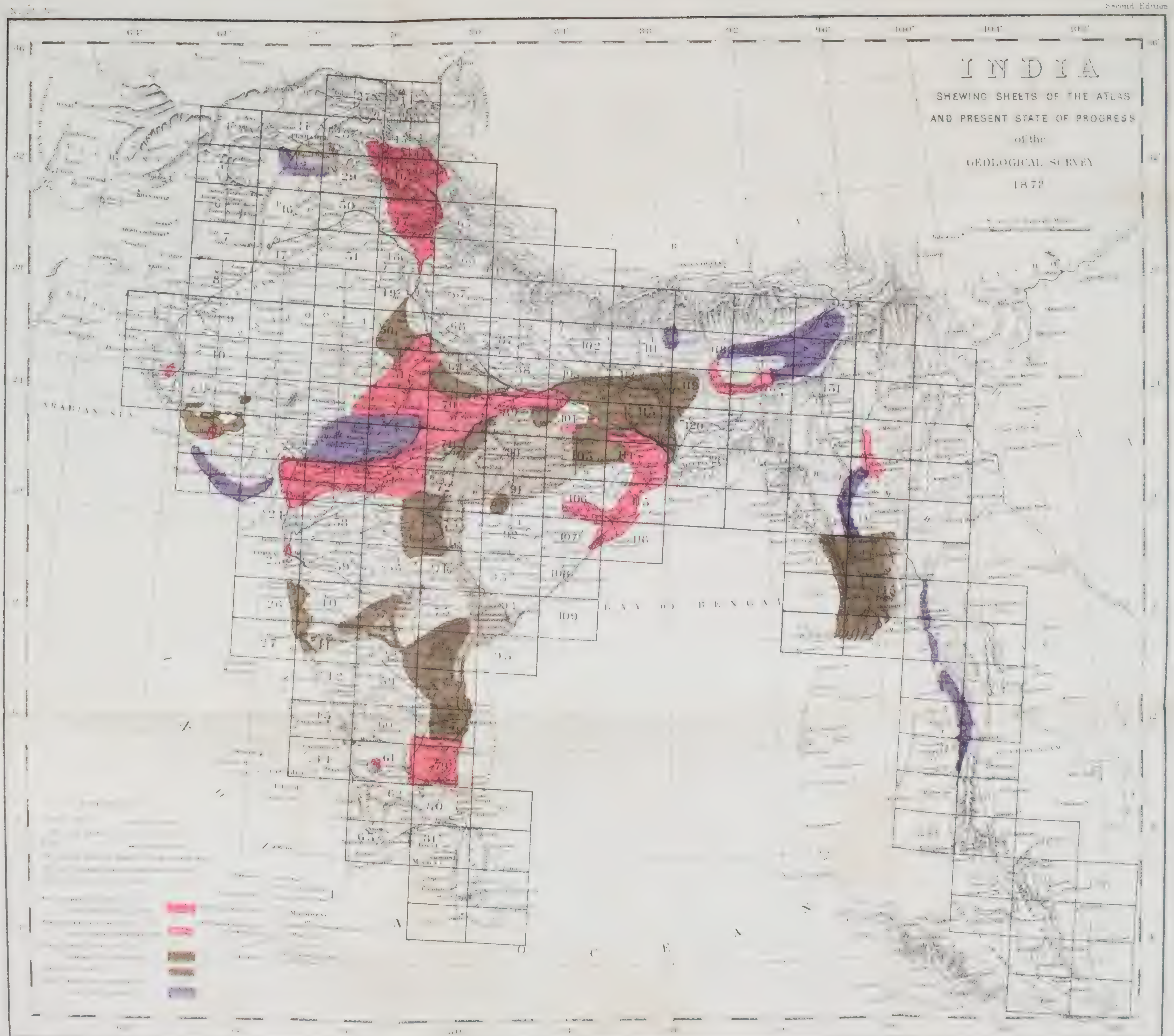
Superintendent of Geol. Survey of India,
and Director of Geol. Museum, Calcutta.

CAMP, GODAVERY RIVER,
17*th January* 1872.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1871.

BATAVIA.—Royal Society of Batavia.
BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Royal Academy of Science.
„ Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
COPENHAGEN.—Danish Academy.
DEHRA DOON.—Trigonometrical Survey of India.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
EDINBURGH.—Royal Society.
„ Royal Scottish Society of Arts.
FLORENCE.—Geological Society of Italy.
GLASGOW.—Philosophical Society.
LONDON.—Royal Geographical Society.
„ Royal Society.
„ Royal Asiatic Society of Great Britain and Ireland.
„ Geological Society.
„ Society of Arts.
„ British Museum.
MONTREAL.—Geological Survey of Canada.
MOSCOU.—Société Impériale des Naturalistes.
MÜNICH.—The Bavarian Academy.
NEUCHATEL.—Society of Natural Science.
PARIS.—Comm. des Annales des Mines.
PENZANCE.—Royal Geological Society of Cornwall.
PHILADELPHIA.—American Philosophical Society.
„ Franklin Institute.
„ Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
SALEM.—Essex Institute.
TORONTO.—Canadian Institute.
TURIN.—Academy of Turin.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—Kais. Akad. der Wissenschaften.
„ K. K. Geologische Reichsanstalt.
„ Zool. Bot. Society of Vienna.
WASHINGTON.—Smithsonian Institute.
„ Department of Agriculture of the U. S. of America.
ZÜRICH.—The Natural History Society.
Governments of India, Bombay, Bengal, N. W. Provinces; Chief Commissioners of Oude, British Burma, and Mysore.

Second Edition



ROUGH SECTION SHOWING THE RELATIONS OF THE ROCKS NEAR MURREE (MARÍ), PUNJAB, by WILLIAM WAAGEN, PH. D., *Geological Survey of India.*

(NOTE.—For the information of many who frequent the Sanatorium of Murree, and who may be interested in the geological structure of the hills in that neighbourhood, we give the following description of one easily accessible section close to that hill-station, the true relations of which have hitherto puzzled many observers, owing to the numerous contortions and fractures to which the rocks have been subjected. This one section will, it is hoped, serve as a key to others, and the vast importance of fossil remains as indicating the true position of the beds in which they occur, once recognized, it may fairly be hoped that greater care will in future be taken, not only in searching for these, but still more in accurately establishing the beds from which they have been taken,—a point hitherto sadly neglected).

The deposits on which Murree is built consist of red, clayey slate, with thick sandstone layers in it. These deposits are certainly younger than the Nummulitic beds, which decidedly dip under the former. It is difficult to say anything more definite as to their age, every trace of fossil (except a few bones formerly found, as I am informed) being wanting. (They are probably the representative of the true Siwaliks, further to the east). The thickness of this formation is great, but there are so many faults and contortions cutting through it that we cannot say how many times the same series is repeated, and cannot, therefore, determine its thickness with any exactness.

The true Nummulitic limestones are cut off from this formation mostly by enormous faults, so that it often seems as if the red layers were dipping under them, but in other places the superposition over the Nummulitics is very clear.

The ridge of mountains upon which Murree is built is entirely composed of these red sandstones and shales. The next ridge to the north-west, however, is, for the greater part, formed of Nummulitic limestone, which, at short intervals, is interrupted by thick beds of grey or greenish shales, in some places crowded with *Nummulites*. Even at the lowest portions of the red shales, there are some calcareous bands, which contain, but rarely, *Nummulites* and some badly preserved Pelecypods, (mostly *Lucina*), and Gastropods, (*Pleurotoma* or *Fusus*), and some fragments of Crustacea. The richest bed of the *Nummulites*, which is a greenish-grey clayey shale, appears to be rather in the upper part of the whole formation, while the lower part is composed of more compact, grey limestones, which look exactly like Triassic limestone, but which are, for the most part, crowded with organic remains, chiefly of undeterminable species, among which a very small *Nummulite* is prevalent.

In most cases there is at the base of the Nummulitics a band of black, coaly shale, of not more than from three to five feet in thickness.

Below this is a very considerable mass of sandstone in thick beds, outside yellowish-brown and of rusty aspect, but blue in color on the fresh fracture. This sandstone is, in some places, at least 100 feet in thickness. There are no palæontological indications of the age of this sandstone, but it always occurs in such close relation to the 'Spiti shales' that I am inclined to consider it of jurassic age: more especially as Dr. Stoliczka has found, in Spiti, similar sandstones, which he calls 'Upper Jurassic.'

This sandstone, if jurassic, is often the only representative of this formation, the Spiti shales, at its base, being so much crushed, that they almost entirely disappear, or they assume an aspect quite different from that which they commonly present.

The 'Spiti shales', which follow immediately below the sandstones, are of very typical aspect; black shales, with clayey concretions, impregnated with iron. The concretions which are not very distinct from the surrounding shale are not very hard, and do not, as is the case in Spiti, contain the fossils. On the contrary, the fossils here are all compressed between the single layers of the shales. At their base these 'Spiti shales' show a certain amount of transition to the next lower formation by some beds of a calcareous sandstone and limestone intermixed with yellowish-grey shales. The limestones then

become predominant, and show, about 100 feet below the shales, some very fossiliferous bands. It is, however, impossible to obtain anything determinable out of the rock, but on the weather-worn surfaces, I observed numerous specimens of an Oyster, which I consider to be *Ostrea Haidingeri*, as well as several other things as yet undeterminable. I have little doubt that these limestones are Triassic, although the palæontological evidence is still very small. But the general aspect of the whole group is so entirely like some portions of the Upper Trias in the Alps, and further, as there are Triassic beds of the Alpine type, well known in the Spiti districts of the Himalaya, I do not hesitate to place these limestones in the Triassic formation. I have seen no sections in this neighbourhood which go deeper than the Trias.

To give a single and easily accessible section bearing out the statements just made, I will describe a line, of which a very rough sketch is given in the accompanying figure. The first glance will show what enormous contortions and faultings the rocks in this district of the Himalaya have undergone, and how difficult it must be to trace the succession of the layers, when they are cut through by faults at nearly every 100 paces, and when these faults are not visible at the surface. The scale to which the section is drawn does not allow of all the contortions which exist in reality being shown. I was compelled to limit myself to the principal ones, which determine the succession of the layers.

Starting from the Bazaar of Kaira-gully, by the backroad which leads round the Chumba Peak to Chungly-gully, one is able to observe in the first two miles of the road the following section:—

(1, 2.) At the corner, where the road branches off from the village and descends on the slope of the mountain, are some Nummulitic shales and limestones, of grey and greenish color, dipping to the north, and here and there with layers full of a small species of *Nummulite.* The Nummulitic rocks continue for some hundred paces, frightfully contorted and dipping in several directions. At last

(3.) A thin band of an entirely black, coaly clay-shale, about two feet in thickness, appears, indicating the base of the Nummulitics.

(4.) Below this a series of hard sandstones, brown on the surface, and bluish-grey inside, are observable along the roadside, intermixed with greyish shales, and here and there with a more calcareous band. The dip is uncertain and varied; often they are vertical.

(5.) After these one meets grey limestones with intercalated grey slate layers, and bands full of fossils, among them *Ostrea Haidingeri*, another Oyster, and several other Pelecypods and Gastropods, in a very bad state of preservation.

Going further along the path, the series is broken off, and, near the point A, a large fault must cut through the rocks, although this is not visible on the surface, everything being covered by débris.

Beyond the point a new series begins. The first thing which appears are a few broken-down bands of sandstone. Then follow, nearly horizontally,

(6). Spiti shales, between sandstones of nearly the same description as No. 4, both on the top and at the base, the band at top being, however, very thin. The shales contain fossils, but they are very rare. Dr. Beveridge, R. A., also tells me that he found at this spot, some time ago, a few *Ammonites.*

Above the upper sandstone follows

(7). A series of grey shales and nodular limestones, with many, but very badly-preserved, fossils. I collected here a little *Avicula* and some *Oysters.* Further on, from the road one can see very clearly that the whole of the Spiti shales and the other rocks have been overthrown, and that the lowest part of these shales, and the transition from them into the Trias, is here exposed. A little space is then covered with débris, and then typical Triassic rocks (= No. 5) are visible, thrown into a vertical position. With this the second series finishes, and the whole is again cut off by a large fault at the point marked B.

The third group begins again with Spiti shales (below them occur Triassic rocks indistinct), which are here highly fossiliferous, and dip at a high angle to the north. Here I collected *Oppelia acucincta*, Strachey, *Perisphinctes frequens*, Opp. conf., *simplex*, Sow., *Belemnites Gerardi*, Opp., *Inoceramus*, *Cucullæa*, *Pecten;* all common species of the 'Spiti shales.'

Above the shales are the sandstones, described at No. 4, well exposed and more than 100 feet in thickness. They make a slight curve, showing a little bit of 'Spiti shales' below, and then dip down at a high angle. Below on the slope of the mountain the shales are again visible, divided into two stages by a thick calcareous band; the thickness of the shales is here very considerable.

This part of the section is obviously not overthrown. And, therefore, it is clear that the portion of the shales which has furnished the fossils is the uppermost or highest.

Higher up in the next 'khud,' some more black shales are visible, but it remains doubtful whether they are not cut off by faults.

At the point marked C a great fault again cuts off the whole section, and further on, Triassic limestones appear dipping to the south-west.

The mountain-top appears to be formed of the Nummulitic limestone.

This single section will sufficiently show the difficulties which attend the study of the geological structure of these regions. It is so far a satisfactory result that we are able to show that the Nummulitics lie above the Jurassics, and the latter above the Triassic. It is as yet utterly impossible to go further than this and attempt to distinguish certain stages within the Mesozoic formations of this area.

MURREE,
November 1871.

MINERALOGICAL NOTES ON THE GNEISS OF SOUTH MIRZAPÚR AND ADJOINING COUNTRY, *by* FRED. R. MALLET, *Geological Survey of India.*

In comparison with the gneiss of many other portions of the country, which presents a singular dearth in mineralogical variety, that of the Rehr valley offers to the mineralogist a tolerably rich field. The number of species known to exist in the area now surveyed is pretty large, and further exploration will probably increase it. The following is a complete list of those found up to the present time, showing their association and mode of occurrence, but I will confine my subsequent remarks to those to which some special interest attaches:—

I.—Occurring as constituents of the gneiss.

Quartz—Orthoclase—Oligoclase—Muscovite—Biotite—Hornblende—Epidote ?.

II.—Occurring in beds in the gneiss.

Limestone—Corundum—Magnetite—Quartz as quartzite and quartz schist—Hornblende as hornblende rock, tremolite rock and jade—Mica as mica schist—Epidote.

III.—Occurring in veins in the gneiss.

A.—In quartz veins and reefs—Quartz.

B.—In pegmatite veins (as constituents)—Orthoclase—Oligoclase—Quartz—Mica.

C.—In epidotic veins—Epidote—Quartz.

IV.—Accidental minerals in the gneiss.

Magnetite—Ilmenite—Schorl—Garnet—Stilbite ?.

V.—Minerals occurring in the subordinate beds (II) of the gneiss.

α.—In the limestone—Magnetite—Pyrites—Hæmatite—Serpentine—Chrysotile—Phlogopite ?

β.—In corundum bed—Schorl—Euphyllite—Diaspore.

γ.—In jade bed associated with Corundum—Corundum—Rutile ?—Schorl—Euphyllite.

VI.—Occurring in the veins, &c., in the gneiss.

α.—In quartz veins—Micaceous iron—Tremolite—Augite—Epidote—Schorl—Muscovite.

β.—In quartz reef—Galena—Cerusite.

γ.—In pegmatite veins (as accidental minerals) Schorl—Garnet.

Felspars.

Two felspars are often coexistent in the gneiss and in the coarse pegmatite veins by which it is traversed. One, orthoclase, generally forms the greater proportion of the rock, and is seldom or never absent. The usual color is some shades of pink or red, but it passes not unfrequently into pure white. The other, oligoclase, is not a constant ingredient of the rock, and where it does occur, it is present in much smaller proportion; it is always white in color, weathering with a dull opaque surface from superficial alteration into Kaolin, and on such altered face, it is markedly distinguished from the orthoclase which weathers far less readily. On a fresh fracture the two minerals are less easily distinguished, particularly when the orthoclase also is white. The striæ characteristic of triclinic felspars are often prominently marked on the oligoclase. The following is an analysis by Mr. Tween from a specimen out of one of the pegmatite veins:—

Silica	66·24	
Alumina	20·72	
Lime	3·56	= Soda 14·65.
Potash	2·26	
Soda	9·22	
	102·00	

Mr. Tween's determination of the alkalis in similar felspar from Bundlekund gave—

Soda	13·33	= Soda 15·14.
Potash	2·76	

Micas.

The mica is usually biotite, and black or dark-brown in color. It generally occurs in small laminæ, but occasionally crystalline layers or single crystals occur with cleavage faces one-half of an inch or one inch across. Muscovite sometimes takes the place of the above, but it is less common.

The mica is sometimes associated with hornblende, and thence by gradations the rock passes into hornblendic gneiss. In the gneiss which is associated with the limestone of the Bichee Nuddee, large crystals of hornblende two or three inches across occur.

Epidote.

A very handsome epidotic rock occurs in a few places, which may perhaps be granite, but I never obtained a clear section showing what its true relations are. It is found in low hillocks to the south-west of Pokhra, being there composed of pink felspar and epidote with a little quartz. Traces of foliation (or which seem to be such) can be seen, but they are faint. Thin veins of epidote with quartz sometimes intersect the gneiss both obliquely and parallel to the bedding. Sometimes the sides of the vein are of epidote, while the centre is of crystalline quartz, the summits of the crystals pointing towards each other with a hollow in the centre as if the vein had been produced by infiltration.

Epidote as a rock in itself has been obtained in only one instance, where it occurs as a bed in the gneiss of a few feet thick.

Limestone included minerals.

Of the bands of limestone hitherto met with in the gneiss, the most remarkable is that near the mouth of the Bichee Nuddee, a stream which falls into the Rehr near Singrowlí. The rock, which is a white marble, afforded on analysis the following composition:—

Carbonate of lime	53·85
" magnesia	45·78
" iron	·34
Insoluble (chiefly minute scales of mica)	1·00
Total ...	100·97

being, therefore, a typical dolomite.

It is interbanded with serpentine of a rich green, and occasionally, but rarely, of a rosin-brown tint, constituting a fine verde-antique marble. The purely calcareous and the serpentinous layers, say from about an inch to a foot in thickness, or in places the serpentine, occurs disseminated in spots through the limestone. Associated with the latter are layers of tremolitic hornblende passing in places almost into diallage; these hornblendic bands being traversed by irregular veins composed of quartz and largely crystallized white and flesh colored orthoclase. The limestone contains large and brilliant crystals of greyish tremolite (the tremolite in the hornblendic layers being light-green) and also large masses of a bronze colored mica, which from its occurrence in crystalline limestone, its color, and the comparatively faint degree in which it exhibits biaxial characteristics, I believe to be Phlogopite. Magnetic iron with pyrites also occurs, but sparingly. In the serpentine silky layers of light-green chrysolite of $\frac{1}{4}$ or $\frac{1}{2}$ inch thick are frequently met with.

Slabs of marbles transverse to the bedding, and thus showing the alternation of limestone, and serpentine might be got to any extent of three feet across and with a little selection of five or six feet or possibly even more. The rock is quite free from silicious geodes, and would thus admit of easy sawing and grinding.

Fine grained gneiss with hornblende schist and containing crystals of hornblende two or three inches across is in contact with the limestone, the rock being so jumbled up that if the gneiss were not well foliated, one might easily fancy it to be intrusive granite.

Several other bands of limestone have been met with, of which some are serpentinous. Others again are pure white, constituting a valuable marble.* One of these latter is crossed by the road from Singrowlí to Mirzapúr a few miles from the former town.

On the right bank of the Rehr a little below Saipúr, there is a fine band, some 25 or 30 yards thick, of white crystalline marble with serpentinous layers, which may be traced for a considerable distance along the bed of the stream.

Corundum and associated minerals.

I cannot yet give a full account of the corundum bed at Pipra, as it is not included in the area geologically surveyed, and I was only able to pay a hurried visit to the place. The rock occurs in a small hill between Pipra and Kadopani (sheet 18, Rewah Survey) and about a mile east of the Rehr, the beds here having a rather irregular strike about east-west.

The section across the hill from south to north is as follows:—

a.—White quartz schist.

b.—Hornblende rock passing into jade, a few yards thick.

c.—White tremolitic quartz schist breaking with a fibrous fracture.

d.—White and green jade, including some purple corundum and containing euphyllite and schorl. The coloring matter of the jade is clearly the same as that of the mica (oxide of chromium); *c* and *d* are about equal in thickness to *b*.

e.—Bed of corundum several yards thick. It is a reddish, sometimes purple or grey, rock almost compact and crystalline in texture, and containing emerald-green euphyllite and sometimes schorl and diaspore in the seams.

f.—Porphyritic gneiss with hornblende rock. I hardly think that the corundum is in direct contact with the gneiss, but it is seen within a few feet of it, the intervening space being obscure.

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* White granular limestone also occurs in the slate veins. A very fine mass may be found at the east end of Oobra Hill, two or three miles from the Mirzapúr road.

The corundum bed is several yards thick, the surface of the hill being covered with blocks, some of which are not less than 2 or 3 tons weight, and the supply is practically inexhaustible. I was informed by a brother of the Rajah of Singrowlí, who lives at Kotah, that no corundum had been worked for five or six years, until last year, when 125 bullock loads were taken to Mirzapúr. A load is three maunds, the total, therefore, being about $13\frac{1}{2}$ tons. The mahajuns pay for it at the spot $2\frac{1}{4}$ rupees per 14 kucha maunds (=7 pucka maunds of 40 seers), or at the rate of 18 shillings a ton.

When two pieces of the corundum are rubbed or knocked together in the dark, a very beautiful crimson phosphorescence is emitted. When struck pretty hard yellow sparks are also thrown off, which are quite distinct from the crimson light, the latter being elicited by the slightest tap. The same effect is produced more brilliantly by striking the stone with a hammer, when the crimson light and yellow sparks flash out at every blow sufficiently hard to produce the latter. The sparks resemble those from a flint and steel, while the crimson light is true phosphorescence; this red light is so characteristic as to be of considerable use as a rough field-test for recognizing corundum. Quartz, and such other common silicious minerals as I have examined which phosphoresce at all, give a yellow or greenish-yellow light.

In 1868-69 I was informed that corundum was also obtained at Beejpúr in Mirzapúr on the right bank of the Rehr. On visiting the spot my guide took me down into one of the nullas in the alluvium and showed me several lumps lying about, but I could find none such *in the alluvium itself*, or in any bed in the gneiss of the neighbourhood from which the above lumps could have been derived. This year in conversation with a very intelligent Zemindar of Beejpúr, I mentioned the above facts, for which he furnished what seems to be a very plausible explanation—namely, that some years ago some bullock-loads of corundum from Pipra (eight or ten miles to the west) had been thrown away at Beejpúr by some brinjarries on account of more profitable employment for their bullocks or some other reason.

The emerald-green mica which occurs in seams in the joints of the corundum has been analysed by Mr. Tween, who found its composition to be as follows:—

Silica	43·53
Alumina	43·87
Oxide of chromium	·91
Lime	1·45
Potash	7·80
Water	4·60
	102·16

The high percentage of alumina and small one of silica is what might be expected in such a mineral in association with corundum, and the above composition closely coincides with that of the mineral named Euphyllite by Professor Silliman, Jr., which occurs at Unionville, in Pensylvania, in exactly the same association as our Indian one, namely, with corundum and tourmaline. The chief difference is, that the alkali in the American mineral includes both potash and soda, while in the Indian one it is wholly potash. In the mica, however, found by Dr. Smith with the emery of Asia Minor, which he originally regarded as muscovite, but on further investigation referred to Euphyllite, the alkali is almost wholly potash; the presence of 1 per cent. of oxide of chromium to which the Indian Euphyllite owes its color, distinguishing it from that of both America and Asia Minor. The following are its chief characters:—Structure micaceous; hardness = 3·5—4·0;

lustre on cleavage surface pearly, on lateral faces vitreous; color emerald-green and sensibly monochroic. The color is the same whether the light passes perpendicularly or parallel to the cleavage faces. Transparent in plates of moderate thickness. Biaxial; yields water in a glass tube. In platinum forceps emits a starry light, loses its color, and falls on the edges.

The tourmaline associated with the above is jet black with rather brilliant lateral faces, and often has a columnar structure parallel to the direction of the seam. Diaspore has also been observed, but as yet in too small a quantity to admit of description.

Euphyllite and tourmaline occur also in the jade bed *d*, the former as a scaly aggregate and the latter in a massive form. Microscopic crystals with metallic lustre and red color are observable, which appear to be white, but they are too minute to admit of chemical examination.

If I should revisit the Sone Valley next season, I hope to be able to furnish fuller information respecting this very interesting as well as valuable bed of corundum and to trace its outcrop east and west from present workings.

Magnetite.

Just north of Korchee (close to the Pangun nuddee, to the east of Gonda Hill) there is a bed of magnetite in the gneiss with a high southerly dip. It is a banded rock composed of alternate arenaceous and ferruginous layers, the latter being granular magnetite. The layers are probably due to bedding, for in a nulla near this, the sand, which is derived from this rock, exhibits a similar alternation of silicious and magnetic sand.

The rock, which is friable, is pounded up into coarse powder and smelted near Korchee, being afterwards worked up into Kolharis, &c. As the powder consists entirely of magnetic and silicious grains, it might be very advantageously washed in the Pangun nuddee, by which process the latter could be easily and rapidly removed and the yield of iron considerably increased. As usual with the natives no flux is used, so that the elimination of the silica would be an important gain.

Hornblende rock, tremolite rock, and jade.

Hornblende rock is very abundant in some parts of the gneiss, often rising into hills on account of its great hardness. Very often, however, it does not do so, and many of the largest hills are of granitic gneiss. Sometimes (*e. g.*, west of Dúmrahur and Urjhut) instead of the usual dark-green color, the hornblende is light-grey, and *tremolite rock* becomes the most appropriate term. The latter again passes into a light-grey or greenish granular to nearly compact hornblende or jade. Such is met with in many places, more noticeably between Kotamowa and Bumnee, and the top of Kurea Ghât, where bands of a foot to a few feet in thickness are interbedded with mica schist, north-west of Kisaree, where olive-green jade occurs, and associated with the corundum of Pipra.

Accidental minerals in the gneiss.

Accidental minerals are not numerous in the gneiss itself. Small crystals of magnetic iron are rarely scattered through the mass of the rock and ilmenite sand has been observed in one or two streams. Schorl is a not unfrequent mineral, and garnet is also to be found in places. It is worth noting that as far as my observation has gone, schorl is confined to the white felspar gneiss and garnet to it and to the hornblende schists, while epidote only occurs in the red felspar gneiss. Pieces of red stilbite have been found in streams, but have never been observed *in situ*. As, however, there is no trap in the district except some doubtful dykes, it is most probable that the stilbite occurs as a secondary mineral in the gneiss itself as a lining of fissures or otherwise.

About three miles west-south-west of Churchuree and one and a half south-west of Chiraikoon in Sirgoojah, near the south-west boundary of Mirzapúr, there is an abandoned lead mine formerly worked by a Mr. Burke. The rock in which it is situated is a reef of light-grey, rather shattered horny quartzite, running west-15°-north, which cuts, parallel to the strike, through rotten-looking earthy micaceous gneiss. At the mine it is double, there being one band of quartzite perhaps 50 feet thick, separated from a smaller one by some yards of the gneiss, which latter is intersected by many shattered strings of quartz. The quartzite bands have a hade of 60° to south-15°-west, the thicker being uppermost, and from the spots which were pointed out to me as those from which the ore had been extracted, it would appear to have occurred in two pockets; one near the lower side of the upper quartzite band and the other near the upper side of the lower, in both cases near the band of gneiss which separates the two branches of the reef. I observed nothing indicating the existence of a regular lode. In some specimens of the quartzite obtained from the above-mentioned spots, the ore (galena) was very sparsely disseminated. Cerusite also occurs in small crystals, and I was informed by the Collector of Mirzapúr that he believed antimony had also been obtained here. Of the latter, however, I observed no appearance.

Lead ore.

DESCRIPTION OF THE SANDSTONES IN THE NEIGHBOURHOOD OF THE FIRST BARRIER ON THE GODÁVARÍ, AND IN THE COUNTRY BETWEEN THE GODÁVARÍ AND ELLORE, *by* WILLIAM T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey.*

[*Continued from page* 115, *Records*, 1871.]

The rocks near Raigúdem differ in no way from those further to the east, nor do they require any description. Coarse sandstones and grits with conglomerates and ferruginous bands are alone exposed. Rocks are seen, for a short distance, in the Pámálerú stream, from its confluence with the Godávarí to just above Genkátapúr, rather more than a mile in a direct line, thence none occur all the way to Págalápali. In the Rálá Vagú which comes from Gúndalpád and joins the Pámálerú near Burgáwái, much felspathic sandstone and conglomerate is exposed, of the usual character with a gentle north-west dip. In one spot nearly a mile from the junction of the two streams some pink and white argillaceous stone is seen in the Rálá. At the junction with the metamorphics to Gúndalpád no Tálchírs are found. The bottom bed of the sandstones seen in the stream is soft and felspathic, grey in colour and conglomeratic with the usual Barákar character, but in a hill immediately to the south coarse loose textured pink and white sandstones are seen which precisely resemble Kámthís.

Rocks near Raigúdem.

The valley which debouches from the mass of hills to the eastward at Gúndalpád consists of metamorphic rocks, like all the more eastern hills, including the lofty mass of Rájgota. But the hills immediately north and south of the valley consist of gritty sandstones. Their eastern boundary passes nearly under Rajgotá, and is continued in a south-south-east direction for some miles; then it turns more to the eastward. From the peak of Rájgota a fine view is obtained over the sandstone country; the jungle clad hills to the south-west are seen extending away for many miles, and the rocks of which they are composed have a low tolerably uniform dip, usually from about 2° to 5°, but occasionally rather higher, to the west and west by north. It is evident with this dip and the direction of the boundary that the beds near Ashráopetta ought to be rather lower in the series than those near Gúndalpád; the former may represent

Hills and valleys east of Gúndalpád.

some of the rocks seen near Amraváram. Their appearance, however, does not support this view, but it should be added that they are very poorly seen, and that there was but little time for their examination.

Rocks near north-east boundary, south-east of Rajgotá.

The sandstone south-east of this, along the north-east boundary of the sandstone area, presents few points of interest. As a rule, the rocks, except where they rise into hills, which is not often the case, are greatly concealed by sandy clay, forming a semi-alluvial plain. The hills, so far as they were examined, are of the usual grit and conglomerate, which form so large a proportion of the field. The boundary is but an approximation laid down by a very cursory survey, and closer examination will doubtless induce its modification. In only one place was any rock seen which had a distinctly Barákar character. This lies south of the village of Bedánol, nearly due east of Áshráopetta, in a stream, and even in this case the rock was only white felspathic grit, unaccompanied by shale or any other typical Damúda formation.

Rocks near north boundary between Raigúdem and Dantalborá.

Leaving the eastern or north-east boundary for the present and returning to Raigúdem, a few words will suffice to describe the rocks near the northern boundary of the sandstone area. The rocks to the west and south-west of Raigúdem are the usual sandstones, grits and conglomerates, more or less ferruginous and possess no distinctive character. To the south stretching away to Págalápali and Múlkalapali is a great sandy plain of jungle in which very little rock occurs. Scarcely any rock too is seen in the Kinarswámi stream.

Tálchírs north-west of Dántalborá.

North-west of Dántalbora there is a considerable tract occupied by Tálchírs. They do not run along the boundary of the sandstones, and it is impossible to say whether they extend as far as the boundary, or whether they are separated everywhere by a belt of metamorphics, as no rocks whatever are seen near the Kenarswámi stream about Dántalborá. Metamorphic rocks are, however, well seen at Gadrágúdanpali, at Koigúdem north of Sompali, and north of Sangam, and they occur in the Kinarswámi or rather in its tributary called the Morair, south of Sangam, so that they probably surround the Tálchír area in the manner represented on the map. The Tálchír beds consist chiefly of the usual shales (mudstones), but just north of Gadrágúdanpali some very fine compact sandstone is met with, which has been quarried to some extent for the anicut at Dúmagúdem. The northern boundary of the patch of Tálchírs is obscure, the country being much covered by sandy alluvium.

Unconformity of Damúdas and Kámthís on Tálchírs.

The mode of occurrence of the Tálchírs not only in this instance, but also on the outside of the sandstones elsewhere, as on the Tál, at Dúmagúdem around Narsápúr, and again on the Ganár stream, and their want of connection in all these instances with the Damúdas, point to an unusual degree of unconformity between the two groups. In the present instance, the higher sandstone beds near Dántalborá are believed to be Kámthís, but on the Ganár stream Damúdas occur, and there is the same absence of Tálchírs at the base of the plant-bearing series, and their presence in an isolated area outside the boundary.

North boundary near Palúnchá.

The range of hills forming the boundary of the sandstones from Palúnchá to Sitarámpúr fort consists mainly of grit. On the hill fort of Sitarámpúr, forming their eastern extremity, some fine red and yellow compact shale of unmistakeably Kámthí character occurs. It is not clear whether the boundary here is a fault or not, but apparently it is natural. The beds dip south close to the boundary, but north on the hill forming the old fort.

From near Palúncha the boundary turns to the northward, and a belt of sandstones, 6 or 7 miles broad west of Palúncha, connects the tract which stretches to the southward towards Ellore and Rágámáhendrí with that which extends to the Godávarí near Managúr, and thence occupies a large area to the north-west and west. The country was merely traversed rapidly and the boundaries very roughly sketched in. All the sandstone seen as far as Alápali and Markod is similar to that near Palúnchá, and the same is found from Markod for fourteen miles in a direct line eastward to Búga. From a high hill two or three miles west of Markod, all the hills in the wild jungly country, for at least ten or twelve miles west and south-west, were seen to be evidently of sandstone; beyond that distance are ranges, the outline of which is less definite, but they are tolerably flat topped and of no great height. For several miles north and north-west of Markod similar sandstone ranges appear. (Markod is north of the Atlas Sheet 94).

Sandstones north-west of Palúncha.

Coal has been found in fragments in the Kinarswámi stream near Alápali, and comes from the hills to the north-west (see Records, 1871, p. 82).

Two or three miles from Ragúndla north-west of Palúnchá, on the road to Kúnáram, chipped implements of the Abbeville type were found in such abundance that 40 were picked up in a quarter of an hour within an area 50 yards square. The spot is in jungle and cut up by small ravines. Many of the implements are of white quartz. Besides those collected, nearly as many more must have been discarded as ill made and imperfect, so that the locality was probably a place of manufacture.

Chipped quartzite implements near Ragúndla.

The south boundary of the sandstone area, running west-north-west from Gháríbpet, was only crossed in one spot near Karkonda. The hills near Gháríbpet consist to the west of garnet and kyanite schist,* the last named mineral occurring in unusual abundance and frequently of good colour. The eastern portion of the same little group of hills is composed of sandstone and grit of the usual character.

Boundary near Gháríbpet.

South of this the boundary can only be traced at intervals, much of the country being covered with thick sandy soil. The metamorphic rocks, which consist largely of a compact hornblendic gneiss, approaching diorite, are more frequently exposed at the surface than the sandstones; the latter are rarely seen except in the hills, which are dotted over the country, and which consist of felspathic grit often conglomeratic. Farther east, within the sandstone area, there is the same paucity of sections; a few fragments of ferruginous grit occur here and there, or quartz pebbles scattered over the surface indicate the existence of conglomerate, but sections are exceedingly rare. In all the grits fragments of clay occasionally occur.

The hill east of Unáparedipalí is of the usual coarse felspathic sandstone, with bands of ferruginous grit (the Kámthí iron bands) and compact red shale: some pink and lilac shale also occurs. Here again the rocks have a strongly marked Kámthí character. The general dip of the hills around this appears to be very low, not more than 2° or 3° to the eastward. About four miles south of Pentlam, on the road to Kistnavâram, in a nulla, a great thickness of the red purple and yellow compact shale is seen, dipping east or east-north-east.

Hills near Unáparedipalí.

At the western end of the tank at Krishnavâram is some very calcareous rock, apparently a schist strongly impregnated with carbonate of lime. This must be just outside the sandstone boundary which probably

Near Krishnavâram.

* This rock was seen and described by Voysey.—J. A. S. B., II, p. 399.

runs through the tank. A hill east of Krishnaváram (probably Kistnáváram), and another further south, are of precisely similar grit to that of which the other hills to the northward are formed. The dip is very slight, if there be any.

From this to Vaimsúr, five miles further south, there is undulating country with a sandy soil, through which no rock appears. At Rajerlá metamorphic rocks occur in a well, and there is a hill of crystalline rock just east of Vaimsúr, but (partly from want of time for more careful examination) no boundary was traced from near Kistnáváram to Chintalpúdi. Near this town metamorphics appear rather more than a mile to the south on the road to Ellore, whilst at the town itself sandstone is seen in several wells. It is felspathic, and the colour is variegated. Thence the boundary makes a curve to the eastward (not examined), and then runs with a rather irregular outline for about ten miles to the westward south of Chatrai.

Country near Chatrai and Núzed.

Around Chatrai (Chataroye of map) the metamorphics are well seen, and to the south of this the boundaries of the sandstone are fairly exposed. There is but little jungle, and the country is mostly open. The bottom beds of the sandstone series are admirably seen in several places, for they rise into low, flat topped hills, the base of which are sometimes of metamorphic rocks, upon which the sedimentary formations are seen resting. This is the case at Rámákápetta north of Núzed (Noozudoo or Noozeíd of the map) and at Ravacharla to the south. Here the lowest beds of the sandstone consist of white, pink and brown felspathic grits, and hard dark reddish-brown ferruginous bands, more or less gritty and conglomeritic. A little further north, as on the hill near Somávaram, and throughout the rises east and south of Núzed, similar beds are associated with variegated felspathic sandstone, fine, white argillaceous sandstone, and red and yellow hard compact shale. All these beds are typically Kámthí in their character, perhaps they resemble the beds at Sironchá more than those of Chánda and Nágpúr, but they differ greatly from the Damúdas of Lingálá and Mádaváram.

Sandstones near Núzed.

The dips are generally low, often nearly or quite horizontal, as in the hills west of Sepúdi. The hills are depicted on the map of absurd height, judging from the hill shading; in reality they are low, flat topped rises, rarely exceeding 100 feet above the plain. The form as represented is also frequently inaccurate in detail.

That the beds are Kámthís, and not of higher horizon as Panchets, is shown by the occurrence of *Glossopteris*, some leaves of which were found in sandstone dug from a well close to Somávaram.

The base of the sandstones is not seen everywhere, for instance, around the tank north of Somávaram and thence to the eastward, and there is of course a possibility of Damúdas occurring in such places. Wherever the basement beds were seen however, they were Kámthís, so far as could be inferred from their mineral character, and there was the usual want of carbonaceous shales and other indications of coal.

Metamorphics, limestone, &c.

The metamorphics were not examined. Some limestone occurs in the crystalline rocks both north and south of Chátrai, (Chataroye) but it looks impure. West and south-west of Núzed the metamorphic rocks form fine masses of hills.

Iron furnaces.

Some iron furnaces at Chítápurn near Cománaram, and others subsequently seen are cylindrical, of greater bulk than usual, being about 4 feet in diameter and the same in height surmounted by a cylindrical chimney a foot or 18 inches in height. The ore is decomposed ferruginous stone

abounding in iron peroxide and probably derived indifferently from the surface of the sandstone and of the metamorphics. The blast is obtained from hand bellows of a larger size than usual, each worked by one man, two bellows to each furnace, the out-turn from each furnace appeared to be considerable, 60 or 70lbs. per diem from sunrise to sunset. It is refined by the same men, not sold in the impure state.

Old Diamond mines at Golapali.

The low rises south of Golapali are covered with the remains of old diggings, said to have been diamond mines. I could not learn how long a time has elapsed since the works had been abandoned; an old man, at least 60 years of age, told me there had been no mining within his recollection, and the pits have all fallen in, the whole country being covered over with thick bush jungle. The diggings appear not to have been in the sandstone itself, but in the very gravelly laterite which rests upon the sandstone, but the surface is so much broken and altered by the pits that it is difficult to say. The workings evidently cover a very considerable area, and are part of the old diamond mines of Golconda,* the ancient name of the hill range north of the Godávarí and the adjoining country.

Rocks north of Ellore.

Similar low flat topped hills of Kámthis extend across the country north of Ellore, becoming gradually less distinct to the eastward. The character of the rocks is precisely the same as near Núzed. South of the low rises, there is a belt, generally three or four miles broad, of undulating grounds, very sandy, and evidently derived from the waste of the sandstone, which is probably but a short distance below the surface. Without closer examination it is difficult to say whether the sandstones can be sufficiently traced in this tract to justify the drawing of the alluvial boundary to the south of it, but probably they can. Thence to the sea all is believed to be flat alluvium.

Country north-east of Ellore.

The hills scattered over the country north-east of Ellore appear to be a continuation of the same Kámthís. Hard ferruginous gritty bands are common, and fragments of them are conspicuous on the surface. In the hills near Kunlácherow, 16 miles north of Ellore, *Vertebraria* occurs in a grey compact hard stone, which appears to be calcareous.

The hill just south of Tándkalpúdí consists of fine hard variegated sandstone, with something of the peculiar vitreous character and conchoidal fracture, typical of particular bands in the Kámthí beds at Bokhárá near Nágpúr, the tank of Taláigáon, near Mángli, and on Malárgar west of Chándá. The dip is to the east and very low, not exceeding 2° or 3°.

South-east of this there is much laterite stretching away to the borders of the sandy alluvium. As a rule, however, laterite is but poorly developed in this country, and there is no well marked belt of it along the edge of the alluvium as is the case to the northward in Orissa.

On the hills east of Ragavápúram there is a very low south-east or east-south-east dip of about 1° or 2°. Twelve miles further to the east-north-east, and north of Gopálapúram, the dip is south or south-south-east. The beds seen in the latter locality are very nearly the base of the series, as metamorphics come in just north of them, and amongst the Kámthís a dark purplish sandstone of fine texture, highly ferruginous, felspathic and slightly micaceous is well developed. The same is seen to a considerable extent in the hills to the north-east near Bímúlú, also close to the boundary. On this rock there is often a coating of

* See Voysey, J. A. S. B., 1833, p. 403; Newbold, J. R. A. S., VII, p. 232.

hydrous iron peroxide, as on laterite. The sandstone hills were seen stretching away to the Godávarí, south of Palavåram, but were not further examined.*

Traps near Pangadi.

The hills west of Pangadí consist principally of trap, overlaid in part by sandstone or conglomerate; underlying sandstone only appears on their northern edge, close to Dúdúkúr. The fossiliferous limestone band is distinctly intertrappean, but at a small height above the base of the volcanic rocks. The trap is fine grained and compact, decomposing into the usual soft earthy greenish rock. All around, so far as was seen, the country is covered with black cotton soil, and agate fragments are scattered about as in the Nágpúr country.

To the eastward the hills are thickly capped with ferruginous grit and conglomerate, precisely resembling that in the Kamthis and probably derived from their waste. This rock is well seen near Daicharla and south of the bungalow at Pangadí. In the latter place it consists of coarse white speckled felspathic sandstone yellowish-brown in colour with ferruginous bands. The trap can be of but little thickness, probably not more than 200 to 250 feet. It is seen on the road from Pangadí to Rajamahendri and reappears north of the latter town, whilst the overlying sandstone appears to form the hills at Dowlaishwaram.

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* I am informed that the sandstone is also found east of the Godavárí in this direction.

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January 6th, 1872.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1872. [May.

Note on the Geological formations seen along the coasts of Bilúchístán and Persia from Karáchí to the head of the Persian Gulf, and on some of the Gulf Islands, *by* William T. Blanford, A. R. S. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The coasts of India, so far as the geology is concerned, may be now said to be fairly known, but hitherto, so far as I am aware,* very little, if any, information has been published concerning the rocks seen on the coasts of the Gulf of 'Omán' and the Persian Gulf. Through the labours of Dr. Carter,† we have a fair knowledge of several points on the south-east coast of Arabia, but the only port visited by him eastward of Rás el Hád, the south-eastern corner of the Arabian peninsula, was Maskát. Dr. Cook has given descriptions of the country around Khelát and several other parts of Bilúchístán, but he did not examine the coast, and Eastern Persia is almost a *terra incognita* even to geographers.

Through the kindness of Mr. H. Walton, Director of the Makrán Coast and Persian Gulf Telegraph, I have had an opportunity of accompanying him in his tour of inspection of the telegraph offices along the Bilúchístán (or, as it is more commonly called, Makrán) and Persian coasts,‡ and of visiting and briefly examining several points of interest, besides the neighbourhood of the various telegraph stations. From the steamer, whilst passing along the coast, the greater portion of the rocks forming the utterly barren hills have been sufficiently well seen to enable them to be recognised as belonging to the same peculiar formation which I examined at Rás Malán, Hormárá, Gwádar, Chárbár, and Jáshk, east of the entrance to the Persian Gulf, and which I believe to be the same as that which I found on the islands of Kishm and Hanjám in the south-eastern part of the Persian Gulf, and on Khárak Island near Bushehr. The mountains behind Bandar Abbás and Lingá on the north-east coast of the gulf are composed of rocks so much resembling in appearance those of the Makrán Coast that I think it probable, with the exception of a peculiar salt formation in Hormuz and the neighbouring islands to be presently described,

* This paper being written away from books of reference, I may have overlooked some previously published description of parts of the Makrán or Persian Coast. It is probable that brief notices of the rocks occur in some of the geographical papers on the shores of the Persian Gulf.

† Jour. Bom. Br. R. A. S., Vol. IV, p. 21, and Geol. Papers on West Ind., p. 551.

‡ I take this opportunity of expressing the very great obligations I am under to Mr. Walton for the facilities afforded to me for examining the different places on the shore, at some of which he stopped solely for the purpose of enabling me to visit them; and I am equally indebted to Captain Bishop, Commanding H. M. S. *Amberwitch*, for assistance of all kinds, the use of boats whenever I wanted them, and especially for aid in dredging.

that the whole Bilúchístán and Persian Coast from near Cape Monze to Bushehr, a distance of over 1,100 miles, and the islands lying off it, consists of the same group of rocks. This group, which is of tertiary age and newer than the nummulitic series, may conveniently be named the Makrán group.

The salt formation in Hormuz and other places in the neighbourhood is far more ancient. Singularly enough, no nummulitic rocks are known to come down to the coast throughout the area described, although Cape Monze near Karáchí consists entirely of them, and I learn from Major St. John that they form the second range of hills inland of Bushehr, between that port and Shiráz, and thence extend far to the southward, perhaps nearly or quite reaching the shores of the gulf near Rás Mutáf. The only other formation observed on the coast is the sub-recent shelly limestone or calcareous grit, identical with that found on the western coasts of India and known at Bombay as "littoral concrete" or "shell concrete." There are thus, in descending order, so far as I have seen, three distinct systems of rocks exposed on the Makrán and Persian coasts; these are, in descending order: 1, littoral concrete (sub-recent); 2, Makrán group (post-nummulitic); 3, Hormuz salt formation (of unknown age). I shall describe each briefly, premising that the Makrán group is the prevailing formation throughout the coast, the other groups being merely local.

Hormuz salt formation.—The island of Hormuz, once the centre of the trade between India and Europe, is one of the most singular places on the surface of the earth. Except at a few spots on the sea shore, it is destitute of vegetation, and consists of a mass of craggy hills of singularly confused forms, but of small elevation, with very few peaks rising above the general level, and of brilliant colours, scarlet and purple predominating. One peak, a little above the rest, is of pure white, as if covered by snow, and some valleys on the westward side of the island are equally filled with a white mass, suggestive of glaciers. Other peaks are black.

In the portion of the island south of the old Portuguese Fort, which I examined, the mass of the hills consist of rock salt, more or less pure, frequently mixed with a reddish earth. Beds of volcanic origin, dolerites and trachytes, some of them much decomposed, are associated with the salt, and some shales and sandy beds are also interstratified. All apparently belong to the same series, but the rocks are much disturbed, beds of salt and volcanic bands alike dipping at high angles. At the spot examined by me the average dip is about 50° to the north-east. On the opposite side of the island, the strike appeared to be nearly the same, but the dip is reversed.

Micaceous iron in abundance is associated with the salt, and I found crystalline masses of anhydrite, and peculiar isolated crystals of carbonate of lime. I had not time to visit the white peak, but I have been assured that it consists of salt.

In the Island of Hanjám, salt-rocks crop out, every here and there, from beneath the Makrán group. They may always be recognised by the surface having fallen in through the washing away of the salt, and the consequent formation of peculiar large crateriform hollows. Upon the beds of the salt series the tertiary rocks of the Makrán group, or at least beds which I believe to belong to that group, are seen resting quite unconformably.

The same unconformity is seen in the large island of Kishm or Jezirah at Tawilah, in which are several outcrops of the salt series, easily recognised, even at a distance, by their red colour and irregular craggy surface, the latter due to their being so largely composed of soluble rock salt. Towards the northern end of the island, at a spot which I visited, there are some large salt caves dug in a bed of very pure rock salt, from which considerable quantities of the mineral are removed for export.

I found a small outcrop of the Hormuz rocks on the island of Túmb. The only place on the main land of Persia at which I recognised the existence of this formation was at Rás Bostánah, north of Lingá. I did not land, but the Commander of the *Amberwitch*, Captain Bishop, took the steamer as close to the shore as he could with safety, in order to enable me to see the rocks, and their appearance and surface were characteristic of the salt series.

I can form no conception of the age of these salt beds: they are much disturbed, but beyond the fact of their being much older than the Makrán group, there is nothing to indicate their geological relations. They appear to be unfossiliferous.

Makrán group of beds.—Cape Monze on the western frontier of Sindh consists entirely of nummulitic rocks, chiefly limestone. Farther to the westward, the beds near the coast have an appearance entirely different from that presented by the nummulitics, the distinction being so great that it may be recognised at a distance of many miles. The prevailing rock along the Makrán Coast is a pale grey clay, more or less indurated, occasionally intersected by veins of gypsum, usually sandy, and often calcareous, occurring in beds of great thickness. With this clay are interstratified bands of shelly limestone, calcareous grit, and sandstone, but these usually form but a small portion of the mass, although their greater hardness makes them conspicuous at the surface. In all sea cliffs and inland scarps the clay is well exposed; thus the magnificent cliff, nearly 2,000 feet high, at Rás Malán, is almost entirely composed of it. From its softness, it disintegrates rapidly, and the usual features of the scenery are peculiar and characteristic. Where the rocks of the Makrán group are horizontal or slightly inclined, the hills near the coast, as at Rás Malán, Hormárá and Gwádar, are more or less flat-topped, the upper surface composed of one of the hard calcareous beds, which are usually dark coloured or become so where exposed, forming a stony plain, often broken up by ravines. Here and there, especially if the harder beds are few in number, isolated blocks of fantastic form stand up above the general level of the hills, precisely as in the horizontal traps of the western ghâts, although the pale, almost white colour of the Makrán clays gives them a very different aspect from that of the black basalts. The scarps around the hills are white or grey clay cliffs, often much concealed by the dark coloured débris of the calcareous bands.

Where, on the other hand, as is sometimes the case,—*e. g.*, near Jáshk and some miles east of Hingláj,—the rocks of the Makrán group dip at considerable angles, the hills formed of them assume a very serrated appearance in consequence of the rapid washing away of the clays and the prominence given to the harder bands. Although this appearance is peculiar, it is less characteristic than that of the flat or nearly flat-topped hills surrounded by pale coloured cliffs.

Locally, a peculiar appearance is produced by vertical veins of gypsum standing up in the clays, but this does not appear to be common.

The "mud volcanoes" of the Makrán Coast have long been known: they are numerous and those seen by me at Chandrakúp appear to consist of the characteristic clay of the Makrán group, which being mixed with salt water, is ejected by means of gas, and dries into cones.

Fossils of Makrán group.—The Makrán beds are evidently of marine origin. They are usually highly fossiliferous, the most abundant fossils being species of *Ostrea*, *Pecten*, and *Balanus*. Bivalve Mollusca, especially forms of *Arca* (several species), *Cardium*, *Lucina*, and species of the family *Veneridæ*, *&c.*, abound, but very often only occur as casts; Gasteropoda, though far from scarce, are less common, forms of *Cerithium*, *Turritella*, and *Natica*

being perhaps the most prevalent. No *Brachiopoda* or *Cephalopoda* have been noticed. *Echinodermata* appear far from scarce; corals also occur, but in no great abundance, whilst *Foraminifera*, although common, are chiefly represented by minute species, the only abundant form observed of frequent occurrence, which is not of very small size, being an *Operculina*. If any fossil character can be selected as distinctive of the formation in general, it is, I think, the frequent occurrence of the cirripede *Balani*.

It must be borne in mind that all remarks upon the fossils of the group are founded on very few and scattered observations, and that any conclusions now drawn may require modification when the rocks are farther examined. Still I think it may be safely stated that the fauna differs entirely from that of the nummulitic rocks. Only a small minority of the fossils [illegible]ined can be identified with the species figured in D'Archiac and Haime's "Animaux Fossiles du Groupe Nummulitique de l'Inde;" and, of these, it remains to be seen whether all really occur in the nummulitic series, for it has long been suspected that some of the species figured by the distinguished French geologists are derived from a higher group than the true nummulitics. The general facies of the Makrán fauna is utterly different from that of the lower tertiaries; the commonest and most characteristic fossils of the nummulitics are *Foraminifera*, especially *Nummulites* and *Alveolinæ*; the most abundant shells in the Makrán group are barnacles, oysters and scallops. No junction of the two series has hitherto been observed, but it may be safely asserted that the Makrán group is newer than the nummulitics, for while the fauna of the latter appears to be nearly, or entirely extinct, at all events in the shallow seas near the coast, several of the Makrán fossils appear identical with species found living, in water of moderate depth, along the shores of Bilúchístán and the Persian Gulf.*

It is possible that the Makrán group represents the Milliolitic deposits of Káthiáwár and the south-east coast of Arabia. Some of the calcareous bands of the former have very much the appearance of "Porbunder stone," and seem to consist, like it, of the casts of minute *Foraminifera*.

Persian Coast of the Gulf, and the neighbouring islands.—It must be borne in mind that, whilst I have little doubts as to the identity of the formations on the Makrán seaboard from near Somiání to Jáshk, my suggestion that the beds seen along the north-east coast of the Persian Gulf belong to the same group rests chiefly upon their appearance from a distance, a very imperfect guide, and one upon which I only hazard an opinion because the rocks have a very peculiar appearance. The only places, where I examined the rocks, were in the islands Hanjám,† Túmb and Khárak. At the first named, the beds closely resemble some of the Makrán group, but the pale clay is in comparatively thin beds and highly calcareous, so as to form a hard compact rock. Of fossils besides the characteristic oysters, pectens and barnacles, a *Cidaris* occurs with very peculiar spines, which are scattered in great numbers throughout one bed in the valley behind the telegraph station. The spines vary so greatly that scarcely any two are identical in form, all have the terminations expanded, and either flattened or cup-shaped, with numerous finger-like processes from the end.

At Túmb, nearly the whole island is covered with subrecent littoral concrete. Beneath this clays are here and there seen, which very probably belong to the Makrán group.

* By the assistance of Captain Bishop, I have been able to collect with the dredge a considerable number of the Mollusca inhabiting the sea bottom. These will doubtless aid in making out the relations of the Makrán beds.

† Henjam, Henkam and Angam of various writers.

The island of Khárak* near Bushehr consists of rocks precisely like those of Hanjám. Littoral concrete covers the level ground near the coast; from beneath it rise thick whitish grey beds of fine argillaceous limestone, or very calcareous clay, capped by coarse dark coloured gritty limestone. Except that the clay is more calcareous, there is no difference in mineral character between these rocks and those seen at Rás Malán, Gwádar and Jáshk. Fossils abound on Khárak, and again the most abundant are species of *Ostrea*, *Pecten* and *Balanus*. More careful comparison than I have had time for hitherto is necessary in order to ascertain whether the species are identical with those of the Makrán Coast, but I think they are, and if any of them are not the same, they are certainly closely allied. With these occur two species of *Spondylus* and several Echinoderms, amongst which the principal are two kinds of *Clypeaster*, a *Scutella* and an *Echinus*. One form of *Clypeaster* is near *C. Halaensis*, D'Archiac and Haime; all the other fossils appear to be distinct from those figured in the "Animaux Fossiles du Group Nummulitique de l'Inde" The *Balanus* may certainly be *B. sublævis*, but the difficulty of comparing fossil *Balanidæ* is well known.

Littoral concrete.—This is an impure loose textured limestone, abounding in shells, casts of shells, and corals of very late tertiary or subrecent date. The majority and perhaps all of the shells found in it are identical with those now common on the coast. It frequently resembles in texture the well known *Calcaire Grossier* of the Paris basin, and, like that rock, is an excellent building stone, indeed several of the towns on the Persian Coast, *e. g.*, Bushehr, are built of it. It usually occupies flat or nearly flat ground close to the shore, and but little raised above the level of the sea, and it is, doubtless, in many instances, simply a raised coral reef.

This formation occurs on the western coasts of India here and there, as far south as Bombay at all events. I did not notice it at the points visited on the Bilúchistán coast, though I am disposed to believe that it is represented near Gwádar by a rather argillaceous bed, of which I have seen fragments abounding in shells. At Jáshk on the Persian Coast of the Gulf of 'Omán, it is well developed, and forms a low cliff about 20 feet high. I found it on the east side of Hormuz, on Hanjám and Kishm islands, and the greater part of the surface of Túmb island appears to be formed of it, it being here, if I am right in the identification, raised much higher above the sea than usual, and slightly disturbed. Bushehr is built upon it, and the eastern side of Khárak island is composed of it. In the last named locality the island is partly surrounded by a "fringing" coral reef, so that the similarity of the raised reef forming the "littoral concrete" and that now existing around the island is striking.

The chief geological interest attaching to this formation is derived from the evidence it affords of recent elevation of land. Reasons will be given in another paper for believing that in this respect the western shore of the Gulf of 'Omán differs from the eastern.

Camp Gwádar, Bilúchístan, January, 1872.

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* Khárg, Karack, Khárij, &c., of various maps. The names in the Gulf are mostly Arabic, and I am informed that where the Arabs use j, the Persians employ k. Thus Kharak or Kharij, Hanjám or Henkam.

NOTES ON A TRAVERSE OF PARTS OF THE KUMMUMMET AND HANAMCONDA DISTRICTS IN THE NIZAM'S DOMINIONS, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

Country bordering right bank of Godavery.

The country referred to in these notes is a moderately elevated and rather thickly jungle-covered tract to the westward of the Godavery river, and lying generally along, but to the south of, the 18th parallel of north Latitude.

Already referred to in Records.

That part of the tract adjacent to the right bank of the Godavery has been already referred to by my colleague Mr. W. T. Blanford.*

Observations mostly made along path from Pálúncha to Narsimpet.

A path traverses the region in a general west-north-west direction from Pálúncha in Kummumet, to Narsimpet in the Pákhál talook some thirty miles east of Hanamconda; and it was along this route that my observations were made, for except around the few villages, up some side paths, or in the dry water-courses, it is, at present, almost impossible to see anything of the country owing to the prevalence of thin tree jungle and undergrowth.

Inhabitants belong to "Koi" tribe.

The few people who inhabit this country are of the "Koi" tribe, which is at present more generally confined to the Bastar Territory to the east of the Godavery.

I took up the further examination of this country at Pálúncha, in the neighbourhood of which place Mr. Blanford had been last season.

Kamthi Sandstones.

Pálúncha is on the coarse sandstones of the Kamthi sub-group already described by Mr. Blanford as extending thence down to Ellore in the Godavery District. These rocks, however, only extend a little distance from the village; and the path to Yellambile passes on to rocks of the "Crystalline series," gneiss of different kinds showing at rare intervals out of the superficial deposits covering the low-lying and slightly uneven country.

Crystallines.

Sub-crystallines at Yellambile.

Near the crossing of the Kinnersammi Vágú, or a short distance higher up the river, there is a good display of rocks which are not so clearly of the gneiss series as those already passed over; and these are found to be associated with highly altered quartzites forming the low hill ridges lying to the west and north of Yellambile and continuing northwards into the lofty group of hills lying between the villages of Munderkheil, Oolavanoor, Mullawárum, and Mámla.

Oolavanoor range, of Vindhyans as well as Sub-crystallines.

Mr. Blanford has noted (on his working map) that part of this range may be of Vindhyan rocks. The southern flanks, at any rate, are made up of quartzites, slates, and schistose beds, which though they have a much more highly altered character than the generality of the Vindhyans, are still not sufficiently metamorphosed to be included in the gneiss series. Occasionally, it is true, some of the quartzites and schists are remarkably like ordinary well-laminated gneiss; but the general aspect of the series is decidedly more Vindhyan in its character.

Belt of Sub-crystallines between Yellambile and Koyergoodium.

The series forms a distinct belt of rocks, having a north-north-east south-south-west strike, between Yellambile and Koyergoodium† (some 9 miles north-west) difficult to be defined by good boundaries

* Records of the Geological Survey of India, Vol. IV, parts 2, 3 and 4.

† As a rule, the names of places as they are given in the sheets of the Indian Atlas, are adhered to in this paper when they are found to agree with the names given by the people. In the region under description the people say *goodium* or perhaps *goodyĕm*; I have never heard '*goodum*,' or *gudem*.

from the gneiss between it and the Godavery, but still separable by constitution and general *facies*.

Same series in Bellary and Nellore Districts.

I have (in previous years) already observed a small patch of like rocks on the eastern edge of the Bellary District, just underneath the western scarps of the Poll Conda range of hills, south-south-east of the Chittrawutty river as it enters the Kadapah District. Here, they are quite distinct from the adjacent granitoïd gneiss and the superincumbent Vindhyan quartzites. Again, on the western edge of the Nellore District, south of the Pennair, there is an extensive belt of similar rocks which I have doubtfully mapped for the present among the Vindhyans of that part of the country.

At Yellambile, includes limestones with Eozonoïd structure.

Close to Yellambile, however, the series is rendered extremely interesting from its including numerous beds of grey limestone which show to the unassisted eye a structure, or arrangement and constitution of the laminæ, exceedingly like that of the *Eozoon Canadense* of still unsettled origin.

A short distance (some 500 yards or so) north of the village, there are several beds of limestone cropping up in the jungle, on either side of the path to Munderkheil. They are striking about east by north, west by south, and are either vertical or dipping at high angles north. or south; while they are traceable to the northward for some short distance, and southwards as far as Gutmulla. Ridges and bands of highly altered and crushed quartzites run between the bands of limestone strata.

Also at Bungarchilka.

Again, some 8 or 9 miles north-west, at the villages of Bungarchilka and Koyergoodium, there is a further exhibition of limestone beds of the same kind; but they do not show the Eozoonoïd structure so plainly.

Aspect of limestones.

Generally, the beds are of pale (weathering darker) grey and white laminated subcrystalline (not saccharine or granular) limestone; the laminæ running easy or parallel with the strike. This, for instance, is the style of the beds nearest to Yellambile; but almost immediately north there are other beds forming a broad belt traceable south-west almost to the Kinnersammi Vágú, which are not simply laminated but have their layers of different matter arranged in waving and undulating lines, rapid contortions, lenticular masses with enveloping laminæ, and knots of all forms. The undulations are equally various on surfaces across, or with the strike.

The harder laminæ, still soft enough however to be scrached with a knife, stand out well on weathered surfaces; and they appear to consist of some form of *Pyroxene*, and are generally of a grey or greyish-green color, and again at times quite white. Some of the laminæ are occasionally of a more decided green color, and they then are possibly *serpentinous*, but this is rare. They are equally unaffected by acid on fresh or exposed surfaces.

The outstanding layers are also themselves finely laminated; and as they widen out often to half an inch or more, they assume a granular form, and are occasionally fringed on one edge. A number of such layers often run together and thus make up a broad seam of irregular laminar-granular structure.

Though not a particularly bright-colored rock, it still shows these characters on half polished surfaces (I could only grind them down so far in camp), and they are then if anything more Eozoon-like.

Much of this limestone is more or less micaceous, and is then somewhat schistose; but neither the direction of the schistose surfaces, nor yet the cleavage which is also exhibited

have anything to do with this lamination which appears to be as distinctly sedimentary as the lamination in any ordinary aqueous rock.

This existence or not of Eozoonal structure must now rest on that closer examination of the rock specimens which could not be made in the field.

Continuation of route past Bungarchilka.

From Yellambile the path runs north-west to Bungarchilka. Thence, after going north for a mile or so, it passes round the northern end of the quartzite ridge north-west of the village, and then enters on Kamthi sandstones.

Kamthis again.

These are lying in easy undulations, or nearly flat, possibly with a general dip of from 5°—10° north, or north-eastward. They cannot be of much thickness between their eastern edge near Bungarchilka and the village of Arlapully, the next place of any size on the road; but they attain a much greater thickness in some ridges and high hills to the north, on whose steeper slopes the lines of out-crop of the beds are very well displayed.

To Arlapully.

Change in sandstones beyond Arlapully.

Arlapully is noticed* by Mr. Blanford as a place where some fragments of coal had been found. I did not know this until some time after having left the village, or a closer examination might have made. However, in the next march, *viz.*, from Arlapully to Goondal or Goondala (some 10 or 12 miles west north-west), there is a gradual change in the appearance and character of the sandstones, even in the rare cases in which they are exposed to view.

Barakars.

These become rather paler-colored, less coarse and tufaceous in their texture and full of iron concretions, when they are indeed very like the Barakar sandstones of Lingala and Madaveram on the Godavery.

The path from Arlapully crosses the Kinnersammi Vágú at the confluence of the Jáléru (from the north), and then it keeps pretty close alongside the right bank of the main stream until it again crosses the river just before passing through the village of Mootapooram.

At Mootapooram.

At this crossing there is a good display of thick-bedded grey and yellow sandstones, some of them rather fine-grained and not unlike Barakars; indeed, from the fact of the beds undulating so easily and there being an evident general dip of low degree to the east and north, throughout the Kamthis up to this, it is highly probable that these pale beds are really of the lower series.

Possibly Coal rocks.

The above is what I noted at the time of passing the place. Since then I have seen the coal area north of Kámárum, to be described further on, and I am still of opinion that at Mootapooram or close by, we have true Barakars, and it is at this village until the bed of the Kinnersammi Vágú has been examined more closely that trial borings might be put down with advantage, if it ever become necessary to search for coal in this wild region.

Easy lie.

The beds are rolling about easily with a dip of 5° or 6°, about north-west, though it is difficult to say what is the true direction of the dip in such irregular beds as these are.

* Records, Geological Survey of India, Vol. IV, Part 3, p. 82.

It is even possible that a seam of coal may show in the place where the large pool of water lies at the crossing; for, I found that the pools of water on the coal area of Kámárum* are all lying on the seams, or close by.

Perhaps a seam of coal at crossing of Kinnersammi Vágú.

That we are near the bottom of the Kamthis, if not below them altogether, at Mootapooram, is soon evidenced, for the large village of Goondala, about 4 or 5 miles further west north-west, is quite close to Vindhyan slates and quartzites. These form the main hill range, a mile or more south-west of Goondala; and a low plateau ridge, immediately west south-west, is made up of coarse, ferruginous, dark-colored Kamthi sandstones.

To Goondala, near edge of Kamthis.

No trace of Barakars was seen in this neighbourhood, little rock being visible in the open flat country around. My examination was however very brief and superficial, as owing to the dryness of the season, I was hurrying on to examine the Kámárum field before all the water in the pools should be dried up.

Barakars not seen.

Goondala is the only village proper on the route; there is a bazaar, &c., and the inhabitants are not exclusively "Kois," as is nearly always the case with the other villages, except Arlapully, where also there is a mixed population.

Continuing westward from this for a couple of miles, there are a few villages, among them Lingoogooram or Lingoogoodium, all of which are just on the boundary between the talooks of Nandyconda (just traversed) and that of Pákhál to the west.

Boundary between two Talooks.

A short distance beyond Lingoogoodium, there is a small hill of Kamthi sandstones round which a stream flows; after crossing this and another wider one, which may be the Kinnersammi, the path begins to ascend, and then crosses a low ridge of Vindhyan slates.

Kamthis cease near Lingoogoodium.

Vindhyans.

No more Kamthis are to be seen for 10 or 12 miles to the west; their general south-western edge trends northwards past the small hill west of Lingoogoodium.

The path now runs through a rather wilder country, still covered with tree, jungle, and coarse grass. The general elevation is about 1,000 feet above the sea, and the surface of the country is rather rugged with low ridges. It is impossible (unless clearings were made) to get a view anywhere to give one a fair idea of position. I got on one small hill which gave a view over a country of apparently endless tree jungle unbroken by any distinct feature, the long range of Vindhyans to the south-west of Goondala being only recognizable. Two or three paths cross this waste of jungle to Kámárum; that followed by me was reported to be the best. It is a mere track occasionally worn into two ruts by the wood-cutters' carts, and much intruded on by trees, so that my packages on the camel's back were much torn and rubbed. Otherwise, there are no difficulties or even dangers.†

Elevated and wild country.

To Kámárum.

* The fragments of coal said to have been found at Arlapully, could not have come down from the Kámárum field, as there is a high water shed between the two places. Kámárum fragments might turn up above Mungumpett, on the Godavery.

† The route, as given in Colonel F. H. Scott's Route Book, is described as rather rugged and dangerous; but this description is of many years ago. However, it is not a path to be travelled during the night time.

Style of Vindhyans.

The rocks are generally reddish and brown earthy clay-slates and a few beds of quartzite sandstone of the Vindhyans, not at all unlike those of parts of the North Arcot and Cuddapah districts traversed by the north-west line of the Madras Railway.

Kámárum.

Kámárum, in the Pákhál talook, is a poor village* in the midst of about the wildest part of this jungle-covered region. It is supposed to be the nearest convenient village to the coal locality of the Pákhál talook.

Coal-field, north north-west of Kámárum.

Without further preface, it may as well be stated at once that this coal-field is very small and ill-placed in every way for its development.

At the most liberal calculation, it is 156 acres in extent, and it very possibly may yield 2,265,120 tons of coal, of which I should say 1,132,560 tons would be good coal, almost as good as that of the Warda R. coal-fields. It is unfortunately lying at the very inconvenient angle of 30° on the average; and the seams are apparently the water holders of the field.

Account of the discovery of coal-field.

This little coal-field was reported to the Nizam's Government by the then Tahsildar of Kandiconda, who gave a tolerably exact account of the occurrence of the coal and the nature of the country. There was great enthusiasm on the subject, and a reward of Rs. 2,000 was at once determined on; but it became doubtful as to whose the reward ought to be, the Tahsildar being supposed to have a great claim. He certainly made a rush at the field as soon as he heard of it, though it was not in his talooks. However, it has now been definitely settled that the reward goes to the Koi men who knew of the coal, and the Banya who got the information from the Kois, by making enquiry on the subject. Under such a fair adjudication of the reward, it may be that further information regarding other seams of coal in this region may now be volunteered.

No other coal near at hand.

So far, there is no more coal in the locality in question, it may be found lower down the valley of the Pungady Vágu, and, as stated above, there are fair signs of it at Mootapooram in the Kandiconda Talook, while the Barakars may crop out among the hills due north of Lingoogoodium.

Position of coal-field.

The coal-field lies about six miles north north-west by west of Kámárum, in the bottom of a wide valley opening northwards, on a main feeder of the Pangady Vágu.

A small patch of Kamthis.

Rocks of the country mainly Vindhyans.

Leaving Kámárum, the path for about 3 miles goes along the plateau top of a spur extending into the valley, over a thin set of Kamthi sandstones and conglomerates which are resting nearly horizontally on Vindhyan slates. This covering of sandstones is only a thin outlier left on the older rocks, which, excepting at the coal-field, are the rocks of this part of the country. At the end of the spur, the path descends a low scarp or step of 30 or 40 feet, and then goes north-west for some distance down into the valley, until it crosses the main stream for the first time.

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* Deserted, while I was there, the "Kois" having migrated to another group of huts not far off. As a rule, these people deserted every village we came to or passed by, but they gradually emerged from the jungle when they found that no harm was meant, and came up to the camp.

Talchirs; trappean.

Here, the course of the stream is over dark green trappean rock (weathering into a mudstone) with dyke-like masses of compacter rock, occasionally laminated and bedded, which is soon seen to be of the Talchir series. True Talchir conglomerates and fine muds occur very shortly after this, especially throughout the course of the river beds, but they are mainly volcanic muds and ashes associated with a great boulder bed of irregular thickness. Higher up come fine dirty green-mud and sandy-mud shales, and then thick beds of fine pale greyish-green sands. The lowest rock seen within the neighbourhood of the river bed is of trappean matter, generally devoid of lamination, of a dark-green color, occasionally nearly black, weathering of a dark-brown or reddish-brown color, of a compact dull stony texture, weathering into a compact sand-stone. This, as well as some of the shales, is occasionally slightly vesicular, or finely tufaceous and containing small fragments of slate and shale. This lower deposit is in places somewhat conglomeratic, but I think the true conglomerate is higher in the series. Over this come a few thin laminated beds of the same style of rock, or as often an 'ash-like' mud-stone rock with large and isolated smoothed fragments of lime-stone, slate, quartzite, and occasionally gneiss and granite. Some of these fragments are very large, as from 4 to 6 feet by 2 and 3 feet, and they are generally lying singly in the finest form of this ash mud. At other times there are the more frequent seams of pebbles and shingle, though these are not crowded together as in an ordinary pebble or shingle bank.

Talchir "boulder bed."

Lowest Talchirs, a form of trap.

Style of the "boulder bed."

This appears to be the representative of the usual 'boulder-bed' in the Talchir series: only in this region the new feature of its having been at times derived from volcanic sources, is I think clearly evidenced. As to the occurrence of the smoothed boulders in the fine mud, one can hardly lay aside the idea so often advanced by my colleagues, but that these were worn and deposited by glacial forces. Two large smoothed and rounded sub-angular masses of Vindhyan lime-stone certainly seemed to me to be scratched otherwise than as from the wear and tear of the river; but I had no means with me for heaving them out of their position to see if the uncovered sides were marked in the same way. It is fair to state that the few boulders of lime-stone (unscratched on their exposed surfaces) which I did displace, were not marked at all on their buried faces. An enthusiastic glacialist would certainly have seen in the Talchirs of this region, a deposit similar to that which is probably being laid down in the neighbourhood of Iceland, for instance, in the present day, where deposits of an undoubtedly volcanic source will be found associated with the debris of an ice-rubbed country.

Trappean and glacial.

The path crosses the river four times in a distance of about 3 miles, Talchirs being traversed all the time; but near the fifth crossing grey Barakar sandstones are met with on the slope of the valley descending again to the stream, and in the bed of the same there is a seam of thinly laminated shaly and stony coal of about 20 feet in thickness, dipping at 30° to 35° south-west by west.

Barakars with seams of coal.

The outcrop of the coal is seen very strong in the river bed as one goes northwards, and after a few yards the dip becomes a little easier. The river then makes a little bend by which the coal runs in under the bank, but beyond the bend it shows again in the river very strong, still with the dip of 30°—35° which, however, rapidly increases to 45° (if not really more beneath). It is about 18 feet thick, close to a narrow gully of the river crossed by a band of sandstones having a

Seam in the river bed.

north-west strike. Here the coal strikes into the land on the left bank; and nothing further is seen down the course of the stream, for a little more than a quarter of a mile of windings, but sandstones lower than the coal, and then beds of the Talchir series.

Three seams of coal lower down the stream.

Still following the stream, however, I found, at about 2,800 feet from the last gap, another sharply angular twist of the river crossing Barakar sandstones; and here the following section is traceable, in ascending order.

At the bottom: The boulder bed of Talchirs overlaid by dirty pale green fine muds, sandy muds, and thick beds of pale gray green fine sandstones. These are generally dipping westward or south-westward in irregular undulations, at 20° to 30°.

Resting unconformably on the fine sandstones are—

(1).	Grey weathering, slightly ferruginously noduled, very coarse, open textured, soft, pale, buff and white felspathic sandstones, with occasional thin layers of pebbles. Variously bedded, sometimes very thick, or thinning out over one another. The beds are somewhat thinner (3'—4') near the top, and more compact	74 feet.
(2).	Thinner flaggy beds of soft sandstone and dark grey or blue sandy micaceous shales	1—2 ft.
(3).	*Coal.*—Thinly laminated, rather stony, and full of patches of a soft velvety charcoal. (This is the seam showing in the bed of the stream higher up)	6 feet.
(4).	Coarse grey sands, thick and thin-bedded, somewhat thinner bedded towards top: at bottom, resting on the coal, a very thick bed, 20 feet or so, of coarse pale grey sandstones, with a few iron concretions	60 feet.
(5).	*Coal.*—(This is throughout the field a thin layer, and it at times thins out in strings into the sandstones).	6—12 inches.
(6).	Coarse sandstones same as those below last seam of coal	15 feet.
(7).	*Coal.*—Similar to lower seam	9 feet.
(8).	Thick beds of coarse grey sandstones	15 feet and upwards.

The upper bed of coal (7) shows in the steep face of the river banks; a fine bed, 6 feet of it exposed vertically, the dip being a little easier here (25°—30°). A little brook from the westward has hollowed back a small cave in the coal.

The middle thin seam (5) is just visible between cropping-up beds of sandstone.

The lower seam (3) is only visible immediately beneath a large cliff of the sandstones, at a sharp turn in the river, where the latter is crossed by a ridgy band of the sandstones below the coal, having a dip of 30° south-west.

The coal has been washed out, and the cleft thus formed is filled with gravel and sand, but the upper part of the seam can still be seen just under the cliff. This cleft is the water-holder of the place, and it is in like spots in the other sections exposed by the river in these coal rocks, that water is now standing.

A short distance further down the stream, the same three seams of coal may, with care, be traced out at different points; here the dip becomes rather easier, while the strike is tending more round to due west. South of this, for a mile or so, there is nothing but Talchirs, and hills of Vindhyans on either side of the valley.

Three seams throughout the field.

After a good deal of searching at the original locality, higher up the river, I found that the three seams of coal are also there, and they are apparently not much reduced or increased in thickness as a whole. The upper seam is possibly a few feet less, while the lower is as stated 20 feet thick. The beds associated with the coal are pretty much the same as those given in the section above.

Following the stream upwards from this for some 100 yards, round a spur on the right bank, there is another watering place under a ledge of sandstones; and here again is the

lower seam of coal, still about 10 or 12 feet thick, overlying sandstones striking across the stream with a dip of 30° south-west. Coal visible in both banks.

Lastly, still higher up the stream, about 6 or 700 yards, a 6—12 inch seam is traceable in the vertical face of some low dipping sandstones on the left bank, at about 4 feet from the ground. This is very possibly the thinning out of the lower seam.

At any rate, not many yards higher up the stream, the Barakars cease altogether and Talchirs form the ground; but these ever extend only a few yards westward, when they are found to come up against Vindhyan quartzites of the main western hill-side of the valley.

8,000 feet of outcrop.

These three or four places down the course of the stream, showing from one to three seams of coal, thus indicate a curved line of outcrop of Barakars of about 8,000 feet in length; the Talchirs hading out to the eastward from underneath them.

Barakars overlaid by Kamthis.

All abut against main western ridge of Vindhyans.

Western boundary.

Breadth of field about 2,500 feet.

Examined at right angles to the strike, they are found in the hollow of this curved line to be overlaid by Kamthi sandstones forming a series of low ridges just behind that point of the stream where the coal was first found. The beds of these ridges, in their turn, dip at the high ridge forming the main western side of the valley. At either end of the outcrop, the coal rocks and the Talchirs are traceable into close proximity with the Vindhyans of the main ridge. The western boundary of this small field of Talchirs, Barakars and Kamthis is then, as nearly as possible, a north-west—south-east line joining the two ends of the curved outcrop; and the greatest cross-width of the area of Barakars and Kamthis is about 2,500 feet. The width of the Talchirs was not ascertained; it is possibly never more than a mile.

The western boundary abrupt, with a steep edge.

I was unable to find any of the upper rocks in contact with the Vindhyans to the westward; but it seemed that this boundary is either a faulted one with a nearly vertical edge, or preferably a natural one, the Kamthis, Barakars, and Talchirs having been deposited in a basin against a steep shore of Vindhyans.

General dip of coal rocks 30° westward.

The dip of the Kamthis in the minor ridges between the river and the main western range of the valley, is still at about 30° westward: so that we are perforce obliged to consider that the coal field throughout has about this average dip; except, perhaps, a little lower, at the northern end, where the beds are striking round west at the main ridge.

Section of thickest part of Kamthis and Barakars.

Continuing the section given above in ascending order, I was able, by going south-west at the main ridge, to roughly estimate that there are about 140 feet of Barakar sandstones over the upper seam of coal (possibly there may even be more seams than those now described) and then 950 feet of Kamthi sandstones.

To recapitulate in descending order:—

Kamthi sandstones	... ...	950 feet.
Barakars	Sandstones	140 „
	Coal	9 „
	Sandstones	15 „
	Coal	6—12 inches.
	Sandstones	60 feet.
	Coal	6 „
	Sandstones	74

Talchirs (thickness unascertained).

This is the thickest part of the Kamthis and Barakars together; the latter thin out to the south.

Area of Barakars about 156 acres.

Supposing that the western boundary has a nearly vertical edge, which I think is the true state of affairs, it may then, without allowing for greater area by the pocket-shaped form of the bottom, and the high dip, be considered that the area of Barakars is about the same as the area of the field in plan; and this is about 156 acres. I think I am very well within the mark by taking 12 feet or 4 yards as the average thickness of coal throughout the two seams together. There are about 4,840 tons in a square acre of coal, 1 yard in thickness; but only three-fourths of this can be got out in the working, so that we may calculate on 3,630 tons, which being multiplied by 156 for the area, and again by 4 for the thickness of coal, gives 2,265,120 tons of available coal. The coal, as described above, is about half shaly, and stony, the shaly being the best; so taking half this number of tons, it may be said that there are available in the Pángadi Vágú field 1,132,560 tons of fairly good coal.

Average thickness of coal may be taken at 12 feet.

Quantity of coal available.

Power of coal in an ordinary fire.

I could only judge of its powers by making ordinary fires (assays will be supplied from the Geological Survey Office by Mr. Tween). These were made before my tent of an evening; it was cold at the time (February) in this elevated region; and with merely a starting of a few sticks of wood, there was very soon a good blazing coal-fire which burnt with a brilliant flame for a long time. It then quieted down into a red-hot fire, with a pale low flame, lasting so for 2 or 3 hours; in the morning the fire was still in existence, but most of the burnt fragments still retained their general form in a heavy light-colored ash. For such a fire, 4 or 5 lumps of coal, each as big as an English brick, were used. The coal can be quarried in large lumps, which will bear rough carriage. The fragments used by me were just dug out from the bed of the river, where the coal must be much deteriorated from that unexposed to the atmosphere.

So far, the favorable aspect of the Pángadi Vágú coal has been given.

Disadvantages connected with the coal of this field, very great.

Dip high, and seams full of water.

Against it there is the extremely high dip, and the fact that as its outcrop is for the greater part of its length either in the river bed or close along-side—the only pools of water in the river being now on the seams—it is extremely probable that even in such an exceptionally dry season as this, the seams are full of water from outcrop to full depth. The area is very small and it is situated in the heart of an elevated and completely jungle-covered region, in which the number of villages, or rather small groups of huts, is extremely small and scattered. The only useful route for the coal to be drawn out is northwards by the valley to Salevoy or Mungumpett. In the present condition of the jungle, work could only be done from early in January to the end of May, as the country is reported to be either highly feverish, or rendered impassable owing to flooding by the rains during the rest of the year.

Area small, and situation very out of the way.

Unhealthy region.

Continuation of route from Kámárum westwards.

From Kámárum, the path continues still westward, first of all traversing the western range of Vindhyans, already referred to, by a cross valley, thickly grown with jungle, through which a clearing has lately been made; and so, across the rest of the Pákhál Talook to Hanamconda. Beyond

the high ridge just crossed, there is a wide stretch of forest-covered, mostly high flat country with occasional shallow valleys and easy descents to other terraces of flat ground, until the more irregularly hilly country in which the great Pákhál tank is situated is reached. This country is all of Vindhyan rocks, mainly earthy slates with bands of quartzite, and one series of slightly magnesian grey silicious limestone having a dip of 5° to 10° south-eastward. The general lie of these Vindhyans is undulating, with a gentle dip to the eastwards: occasionally also high, and even vertical, strata occur, so that they hade up at times in low headlands to the westward.

Vindhyans, and their lie.

The Pákhál tank has been made by throwing a bund across a river, which has cut its way over this western outcrop, between two of these low headlands, and thus there is a noble sheet of water kept back among the few irregular hills bordering eastwards on the line of low headlands. It is a splendid tank: there was no rain to speak of last season, and yet now there is a beautiful and wide-spread sheet of water lying back in two arms on either side of a good big hill east-south-east of the bund: while from these are long bays reaching up behind low ridges of outcropping Vindhyans. On every side there is far-stretching jungle; even below the tank bund, for miles, there is the thickest and densest jungle, only broken here and there by a few patches of rice cultivation. There is not the population even in the country below the tank to make use of its waters; and no careful means are taken in these days of Mahommedan rule to conduct the water to a part of the country, where the population is more numerous. In the old Telingha times, when Warrungul was one of the great centres of the Telugu people, there must have been something more stirring in the way of human life than there is now in this desolate region of wide-spread jungle.

Pákhál tank.

Not more than a couple of miles below the tank, there is a great rectangular fort still standing entire as to its high mud and stone walls, but all overgrown with, and in the midst of, tall tree jungle. The Nizam's Government is at present erecting a large convict jail here, which not being yet ready for its prisoners, and with jungle around, looks almost as desolate as the old fort.

The coup-d'oeil of Pákhál tank is tame, the country being flattish and unbroken by any good hills, except the long low ranges far to the east near Kámárum, and the one large hill at the bank of the tank. In beauty and picturesqueness, it cannot for instance be compared with the great Cumbum tank in the Kurnool District.

The bund of the tank is very nearly on the western edge of the Vindhyans; in fact, the base of the low headlands at the south end of the bund is possibly made up of the bottom beds of the series, in this part of the country; for, about half a mile west of the bund, the stream of water from the sluice is crossed, and here there is very coarse granitoid gneiss of the crystalline series, and these are the rocks which make up the rest of the country westward to Hanamconda.

Western edge of Vindhyans.

Crystallines.

Note on Pákhál tank.—The tahsildar of Narsimpet has obligingly furnished me with the following data regarding this tank from records in his office: "The tank is said to have been constructed about sixteen hundred years ago by Rajah Khaldya. The bund of the tank is nearly 2,000 yards long, breadth 6,000 yards, and the depth back from the bund, 8,000 yards. When full of water, the depth at the sluice is 12 yards."

CAMP GUDDIGOODIUM, 1st *March* 1872.

WILLIAM KING,
Deputy Superintendent, Geological Survey of India.

SKETCH OF THE GEOLOGY OF ORISSA, *by* W. T. BLANFORD, A. R. S. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The province of Orissa consists, geologically as well as geographically, of two very distinct portions,—the one, a belt of nearly flat country from 15 to 40 miles in breadth, extending along the coast, and the other, an undulating area broken by ranges of hills in the interior. The former is entirely composed of alluvial formations, the greater portion of its surface being probably composed of deposits from the great river Mahanaddi and the smaller streams, the Bramini and Baitarni. Near its western limit alone, a few hills of gneissose rock rise from the alluvial plain, especially between the Bramini and Mahanaddi. The inland area, on the other hand, is chiefly composed of rocks of very ancient date, so completely altered and crystallized by metamorphic action, that all traces of their original structure are lost, and any organic remains which they may originally have contained obliterated. The same rocks cover an enormous area in Eastern and Southern India, and are usually spoken of in works on Indian Geology, as the Crystalline or Metamorphic series.

Further exploration in the little known Tributary Mehals will, doubtless, show the existence of beds belonging to other formations, but hitherto the only instance in which any considerable area is known to be occupied by rocks of later date than the metamorphics, is in the tract known as the Talchir Coal Field in the estates of Talchir, Ongúl, Bamda, Atmallik, Radakol and Denkanal. High up the Bramini, a series of very slightly altered or unaltered rocks, comprising slates with jasper, quartzite and schistose beds, are known to occur; but it has not been ascertained whether they extend into the district administered from Katák, though they are believed to occupy portions of Keunjúr and Bonai.

The greater portion of the Tributary Mehals has never been explored geologically, and the information procurable as to their character is most imperfect. It is possible that other coal fields may exist, though not probable. Even the Talchir Coal Field has only received, for the most part, a very hurried examination.

Excluding the formations of which no accurate information has been obtained, such as the slates, quartzites and jasper, believed to occur in Keunjúr and Bonai, the following is a list, in descending order, of the rock systems hitherto described as occurring in Orissa.

8. *Blown sand.*
7. *Alluvium.*
    - *b.*—River Delta deposits.
    - *a.*—Older alluvium of coast plain.
6. *Laterite.*
5. *Katák* or *Atgarh* sandstones.
4. *Mahadeva?* or *Panchet* sandstones and grits.
3. *Damúda* sandstones, shales, and coal.
2. *Talchir* sandstones, shales, silt, and boulder bed.
1. *Metamorphic* or crystalline rocks.

A brief description of the character of each of these formations, as found in Orissa, is appended.

1. Metamorphic or Crystalline Rocks.

These consist of various forms of gneiss, mica-schist, hornblende-schist, quartzite, &c. Crystalline limestone, common in many parts of India, has not been hitherto observed in Orissa. True granite occurs in the form of veins traversing the gneiss, and is of various forms, the most common being a highly crystalline variety with but little mica, and passing into Pegmatite of the kind known as graphic granite, beautiful specimens of which have been found in parts of the Tributary Mehals. This granite is apparently, for the most part, at least of contemporaneous age with the metamorphism of the gneiss. But, besides this, the gneiss itself frequently passes into a granitoid form perfectly undistinguishable in blocks from granite, but which, when in place, is usually found to retain every here and there traces of its original lamination, and to pass by insensible degrees into a distinctly laminated gneiss of the usual form.

Other prevalent forms are ordinary gneiss composed of quartz, felspar, and mica; hornblendic gneiss in which the mica is replaced by hornblende; the latter mineral sometimes forming a very large proportion of the rock, and quartzose gneiss, in which the felspar and mica or hornblende, are in very small proportion and the quartz predominates. This gradually passes into quartzite: a massive rock in general, in which felspar and mica are either wanting or occur only in very small quantities.

The above may be considered the prevailing forms of the crystalline rocks; but there are others of less frequent occurrence. Amongst these are diorite, amphibolite, syenite and a magnesian rock, a kind of pot-stone occasionally resembling serpentine. These may all, very possibly, be of later date than the mass of the metamorphics, though the serpentine-like pot-stone appears to be fairly intercalated.

2. Talchir Group.

The lowest beds associated with the coal-bearing strata are themselves destitute of useful fuel, and well distinguished mineralogically from the Damúda or coal-bearing rocks. They were first separated from the overlying beds in Orissa, and were named after the estate in which they were found. They consist, in the Talchir Coal Field, of blue nodular shale, fine buff or greenish sandstone, and of extremely fine silt beds, often interstratified with sandstone more or less coarse in texture, in thin alternating laminæ. The sandstones often contain felspar grains which are usually undecomposed. In the sandstone and fine silty shale, rounded pebbles and boulders of granite, gneiss, and other crystalline rocks frequently abound, some of them as much as four or five feet in diameter. This remarkable formation is known as the 'boulder bed,' it is peculiar to the Talchir group, and has been found in India wherever that group has been examined; in the valleys of the Damuda, the Sone, the Narbadda, and the Godavari, as well as in that of the Bramini.

Of this singular association of large blocks of stone in a fine matrix, but few other instances are known, the most remarkable one being that of the 'boulder clay' of Great Britain and other countries, which is now by most geologists considered to be of glacial origin. The boulder bed of the Talchir group differs entirely from the boulder clay however; in the former, the fine matrix is distinctly stratified, and the boulders are rounded, neither of which is the usual condition of the boulder clay. But the origin of such a rock is, in both instances, surrounded by the same difficulty, *viz,* that any current of water which could round and transport the boulders would sweep away, instead of depositing, the fine sand, clay, and silt in which they are imbedded. Yet nothing is clearer than that the two were deposited together. Ice is rather a startling power to invoke in endeavoring to

explain the phenomena of rocks found in a tropical climate, but without its agency it appears difficult, in the present state of geological knowledge, to account for the Talchir boulder bed.*

3. Damuda Group.

Above the Talchirs, or occasionally resting upon the metamorphic rocks without the intervention of any other sedimentary beds, are found a series of sandstones and shales, with beds of coal. The sandstones are mostly coarse grey, and brown rocks passing into grits. They are usually more or less felspathic; the felspar being decomposed and converted into clay, and they are often ferruginous. Blue and carbonaceous shales, often more or less micaceous, and ferruginous shaley sandstones are characteristic of this group. Fossil plants, chiefly consisting of Ferns (such as *Glossopteris, Pecopteris*) *Trizygia, Equisetaceæ* and *Calamites*, and above all peculiar stems divided into segments, believed to be roots of unknown affinities (*Vertebraria*), are frequently found. Most of the fossil species found, perhaps all, are characteristic of the Damuda formation.

The peculiar interest attaching to this group of rocks is, however, derived from its being the only one in which workable coal has been found in the peninsula of India. All the coals of Raniganj, and the other fields of the Damúda valley, all those of the Narbadda valley, and of other parts of the Central Provinces, are in Damúda rocks. So far as they have hitherto been examined, the coals of Talchir appear to be of inferior quality to those of Raniganj, the Narbadda and some other localities, but the field in the Tributary Mehals has, by no means, been thoroughly explored as yet.

4. Mahadeva? Group.

Above the coal-bearing series in the western part of the Talchir coal field, there is found a considerable thickness of coarse sandstones, grits and conglomerates, quite different in character from the beds of the Talchir and Damúda groups, and resting unconformably upon them. These rocks are usually coloured of various shades of brown, they are frequently very ferruginous, and the separate beds composing them are massive and not interrupted, as the Damúda sandstones frequently are, by partings of shale. They form hills of considerable size in Radakol.

It is by no means clear that these beds are the representatives of the group in the Narbadda valley to which the name Mahadeva was first applied, but there is a general sub-division of the rocks throughout the greater portion of the Indian coal fields into three principal groups. To the higher of these the term Mahadeva has been given in the Narbadda valley and in Orissa, and Panchet in Bengal, and until re-examination of the Orissa beds has enabled their relations to that of other coal fields to be more accurately made out than was possible when they were first mapped, it appears best to retain the name then applied to them.

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* In 1855 Mr. Blanford suggested (Memoirs, Geological Survey, India, I, p. 49) that these beds might have been deposited on a high table land, and that the association of the boulders was perhaps due to ground ice. The advance of cosmical theories since that time has rather tended to increase the possibility of periods of cold having occurred in the course of the earth's history, some of which may have been sufficiently severe to affect the tropics, or portions of them. The Talchirs have now been found over so extensive an area that the probability of their having been deposited at any considerable elevation above the sea has greatly diminished, and some observers are inclined to consider them marine, a view which I do not share, but at the same time no other hypothesis, not involving ice action, has been offered which accounts satisfactorily for their peculiarities. (Since this was written strong confirmation of Mr. Blanford's views has been obtained, by finding in these Talchir boulder beds masses of granite of large size, the surfaces of which have been polished, scored, and furrowed precisely as are the masses of rocks or boulders, found imbedded in, and transported by, ice-floes or glaciers. T. Oldham).

5. Katák (Cuttack) or Atgarh Group.

South-west of the town of Katák is a considerable area occupied by grits, sandstones and conglomerates, with one or more beds of white or pinkish clay. The beds are very similar in general character to those last described, but there is no evidence of their connection, and it appears at least as probable that the Kâtak rocks are of later date.

No fossils have been found in these beds except some obscure impressions apparently of vegetable origin in the clays.

6. Laterite.

The laterite of Orissa is evidently of detrital origin, and consists essentially of small pisolitic nodules, chiefly composed of hydrated oxide of iron (brown hæmatite) and coarse quartz sand, cemented together, more or less perfectly, into either a firm though somewhat vesicular rock, or a less coherent mass, or at times remaining in a loose gravelly condition, and thus passing by various gradations into a sandy clay with a few pisolitic iron nodules. As a rule, the forms containing most iron are the most coherent, and *vice versa.* The more solid forms are largely used as building stone, having the peculiar but important property of being softest when first cut and of hardening greatly on exposure.

Beneath the detrital laterite, especially when a felspathic form of the metamorphic rock occurs, the decomposed upper portions of the latter are frequently greatly impregnated with iron, and converted into a kind of lithomarge which closely resembles the detrital laterite in appearance, and is employed for the same purposes.

The massive form of laterite which caps many of the higher hills in Peninsular India, and which is more compact than the detrital laterite, is not known to occur in Orissa.

7. Alluvium.

a. Older Alluvium of the Coast Plain.

In the neighbourhood of the hills and frequently for many miles from their base, the alluvium of the plains consists of clay and sand, usually more or less commingled, and, in most places, containing calcareous concretions (kankar or gútin) and pisolitic ferruginous nodules. This deposit passes, as already mentioned, by insensible degrees into laterite on the one hand, and into the more recent delta alluvium on the other, but in its typical form, it is well distinguished from both by being more sandy and by containing nodular carbonate of lime or kankar.

The age of this alluvial deposit is shown by its surface having been modified and rendered uneven by the action of rain and streams; so that the country composed of it is more or less undulating.

Whether this formation, or any portion of it, is of marine origin is a question hitherto undetermined. So far as it has been yet examined, it appears in Orissa to be unfossiliferous. The greater portion has, doubtless, been produced by deposits washed down by streams and rivers from the higher country to the westward, and it appears probable that a portion of these have been deposited along the coast. But other deposits have been, in all probability, formed upon the original marine beds by the additional accumulations brought down by streams and washed by rain from the hills, so that it is questionable whether the lower marine beds, which probably exist, are anywhere exposed.

b. River delta deposits.

In the neighbourhood of the great rivers the soil is finer and the country level, the greater portion of it being yearly overflowed by flood waters and receiving a fresh deposit from them, except in places where they are kept from overflow by artificial means. The alluvium thus formed is generally highly fertile, but the country is swampy and often malarious. As above pointed out, the only character by which this modern alluvium can be distinguished is the flatness of its surface, showing that the area occupied by it is one of deposition and not of denudation. Usually also, it is less sandy than the older alluvium, and kankar is not of frequent occurrence in it, though a thin layer of it often covers deposits of calcareous sand and clays, from which the later deposit can, with difficulty, be distinguished.

8. BLOWN SAND.

Along the coast in places, as about Púrí, large tracts of ground are covered with sand blown inland from the beach. The nature and origin of the formation are obvious.

In proceeding to give a sketch of the geological characters of the different districts and states of which Orissa is composed, I shall first describe the districts of Balasor, Katák and Púrí, and subsequently those Tributary Mehals of which any definite information has been obtained.

1. BALASOR.—Almost the whole district consists of alluvial deposits. Metamorphics occur in the Nilgiri hills, along the western boundary, but they scarcely enter the district anywhere, and in no case are found more than a mile or two within the boundary. Laterite, frequently massive, forms a narrow fringe to the hills in places, but not everywhere.

A few sand hills skirt the shore in the north-eastern part of the district, and on the east of the Súbanrika they extend for three or four miles inland.

The older alluvium occupies the greater portion of the district, the flat river alluvium forming the southern part near the Bytarni, Karswa and Bramini rivers, and a tract in the north-east near the Súbanrika. Around Balasor itself the soil is rather sandy, and contains laterite gravel. Concretionary carbonate of lime (kankar) is widely distributed, especially in the western parts of the district.

KATÁK.—As in Balasor, the largest part of the district consists of alluvium; the older form, with an undulating surface, occupying, however, a much smaller area proportionally, and being confined to the north-western part of the district; nearly all of the remainder being composed of the flat deltas of the Mahanaddi and Bramini. Along the sea coast blown sand generally occurs, but only forms a narrow belt.

Between the rivers Bramini and Mahanaddi in the Killas of Balrampúr, Madpúr, Darpan, Kalkala, Daljúra and scattered over the country to the east in Pargana Ulti, there are numerous hills all more or less isolated, and all composed of gneiss. Along the Bramini, near Balrampúr, and for some miles to the south-east, the rock is compact and granitoid. Further south it is less compact and usually soft from partial disintegration near the surface. It is marked with numerous red blotches, the remains of decomposed garnets. This soft decomposed gneiss is sometimes quarried and used for building. The hills in this part of the country are most inaccurately represented on the Revenue Survey maps.*

No laterite occurs around the more eastern hills, but around those in the neighbourhood of the road from Calcutta to Katák, there is frequently a narrow fringe, often conglomeratic,

* Those on the Topographical Survey maps of the Tributary Mehals, on the other hand, are very correctly drawn.

as if it had been originally a beach deposit, and to the west of the high road to Katák the metamorphic hills are surrounded in general by broad terrace-like flats, frequently stretching from hill to hill, and when they do not do so, affording evidence that the laterite is continued beneath the intervening alluvium. This laterite is frequently employed for building purposes.

PÚRI.—The southern district of Orissa is much smaller in size than either of the others, and yet the extent of hard rocks is larger than in either Katák or Balasúr. All the country near the coast and a broad tract in the north-east of the district are alluvial, but the western parts of the area are occupied by laterite, sandstone, and metamorphic rocks. There is a very small extent of the older undulating alluvium; almost all the eastern part of the district, and the country extending from the Mahanaddi to the Chilka lake is perfectly flat, and consists of the newer or delta alluvium. Hence its liability to flooding from the Mahanaddi. Hills of blown sand extend along the whole coast, and frequently are disposed in two or three principal ranges,—the first close to the shore, the second from one to two miles inland, and occasionally there is another still further from the sea.

The greater portion of Perganas Domipada and Dandimul, south-west of the town of Katák, consist of the Atgarh sandstone, composed, as already mentioned, of coarse sandstones and conglomerates. To the west these beds appear to rest on the metamorphic rocks, and they have a general dip to the east and south-east, at low angles not exceeding 5° or 6°. They are surrounded on all sides by laterite and alluvium. At their apparent base to the west is a coarse conglomerate, the pebbles chiefly of quartzite.

These rocks contain one band at least of white clay, which is largely dug, and used for white-washing houses and for other purposes.

South-west of the sandstone country and west of Khúrda, there is a broad undulating plain, partly covered with laterite through which the gneiss rises at intervals. In the extreme west of the district around Bolgarh and Goriali, there are two very barren ranges of no great height, running east and west, and formed of compact, rather granitoid gneiss.

From this point, whence the boundary of the district turns to the eastward as far as the Chilka lake, only detached hills occur, all of gneiss, with intervening plains of laterite and alluvium. The group of hills near Chatarma are of granitoid gneiss, most of the others are of garnetiferous gneiss with quartzose bands. Such are Khúrda hill and the smaller rises in the neighbourhood, and also the hills east of the Katák and Ganjam road between Rameshwar and Monglajuri.

Precisely similar country extends to the west of the Chilka lake. The lake itself is a part of the sea first rendered shallow by deposits from the mouths of the Mahanaddi and from silt carried up the bay round the hills near Ganjam by the violent southerly winds of the monsoon, and then entirely cut off by a spit, formed, by the same agency, of sand drifted along the coast. Near the south-western extremity of this spit there is a considerable deposit of estuarine shells, at a height of 20 to 30 feet above the present flood level of the Chilka. The shells found, *Cytherea casta* and *Arca granosa*, have not been observed living in the Chilka, and both are estuarine species, not occurring in the sea itself, but the former is now abundant in the estuary connecting the lake with the sea. This deposit appears to afford evidence of a recent elevation of the land.

There can be but little doubt that the Chilka is gradually diminishing in size and in depth, but as it receives no streams of importance, the quantity of water charged with sediment poured into it is small, and its rate of decrease is probably very slow. Its fauna

is peculiar, and deserves more attention than it has hitherto received. Indeed, the whole estuarine fauna of the Indian backwaters and deltas has been but imperfectly worked out, and further information is extremely desirable, of the mollusca above all, for the illustration of the fossils of the many deposits which have doubtless accumulated under very similar circumstances in past times.

Tributary Mehals.

Of the geology of the following states:—

Moharbanj.	Bodamba.
Pal Lahara.	Tigerea.
Nursingpur.	

lying north of the Mahanaddi, and of all the states south of the Mahanaddi river, except Banki, *viz.*:—

Boad.	Nyagarh.
Daspala.	Ranapúr.
Kandapada.	

nothing whatever, definite, is known.

It is pretty certain that a large proportion of their area consists of metamorphic rocks, and it is possible that no others may be found.

Of Keunjúr and Nilgiri, only the edges bordering on the Balasor district have been examined. Hurdole has been traversed, portions of Denkinal and Atmallik have been examined, whilst of Ongúl, Talchir and the little estates of Atgarh and Banki, a somewhat more general survey has been made, still however far from complete or detailed.

Nilgiri and Keunjúr.—The hills bordering on Balasor consist entirely of metamorphic rocks of various kinds. In the northern part of the range gneiss is found, so granitic that the direction of the foliation can scarcely be ascertained. It appears to be nearly parallel with the escarpment of the range.

Granite veins are scarce, but green-stone dykes or pseudo dykes, many of them of great size, abound, and most of them, if not all, appear to be parallel with the gneissic foliation. This fact renders it probable that the dykes in question are really beds so altered as to be perfectly crystalline.

A kind of magnesian rocks, intermediate in composition between potstone and serpentine, approaching the former in appearance but less greasy in texture, is quarried to some extent chiefly for the manufacture of stone dishes, plates and bowls. These stones are roughly cut into shape in the quarry, and finished partly with tools, partly on a lathe in the villages. The rock employed occurs, interfoliated with the gneiss, in several places, and is quarried at the villages of Santragodia and Gujadiha, a few miles south of Nilgiri, at a spot two or three miles from Júgjúri, and in scattered localities to the north-west.

A few miles west-south-west of Júgjúri, near Parkpada, the granitoid rocks are replaced by a tough, hard, indistinctly crystalline, hornblendic rock resembling diorite, but exhibiting more foliation than is seen in the hills near Nilgiri. Still further to the south-west, quartz schist comes in, well foliated, occasionally containing talc. A detached hill near Bakipúr consists of this rock, and so does the whole south-west portion of the range as far as Rugadi, except in the immediate neighbourhood of the Salandi Naddi, where it leaves the hills. Here syenite occurs, and the same forms a detached hill near Darapúr. The south-western portion of the range is free from the trap dykes, which are so conspicuous in the north-east of Júgjúri.

All the western portions of Keunjúr are unexplored.

Tálchír, Ongúl, and Atmallik.—*The Tálchír Coal-field.*—These states comprise by far the most interesting geological area in Orissa and its dependencies. The basin of sedimentary rocks known as the Tálchír coal-field is surrounded on all sides by metamorphics. This basin extends about 70 miles from west by north to east by south, with a general breadth of from 15 to 20 miles, its eastern extremity at Karakprasad on the Bramini river being nearly 50 miles north-west of Katák town. Its western limit is not far from Rámpúr in the state Rádákol, and it comprises nearly the whole of Tálchír and a considerable portion of Ongúl and Rádákol, with smaller parts of Bamda, Atmallik, and Denkinal.

The western half of this field, or more than half, is chiefly occupied by the rocks already described as belonging to the Máhádévá group;* conglomerates and coarse sandstones, which form hills of considerable height in a very wild, jungly, and thinly inhabited country. It is by no means improbable that the Damúda coal-bearing rocks will hereafter be found in portions of this area. Indeed, they have been observed at the village of Patrapada.

In the extreme west of the field Tálchír beds occur in the upper part of a valley tributary to the Tikaria near Deincha, and also near the village of Rámpúr in Rádákol. In both cases Máhádévá rocks appear to rest directly on them without the intervention of any Damúdas.

Besides occupying the western part of the field, the Máhádévás are found in two places along the northern boundary, which is formed by a fault of considerable dimensions. One of these places is near the villages of Bodaberna and Dereng, where the upper beds occur as a narrow belt five or six miles from east to west, their presence being marked by low hills of a hard conglomerate. Farther to the west, they recur in another isolated patch forming the rise called Konjiri hill and its neighbourhood. This hill consists of sandstone capped by conglomerate, the pebbles from which weather out and cover the sides of the hill, concealing the sandstone beneath.

The northern part of the field on which these outliers of the Máhádévás occur is much cut up by faults, or, to speak more correctly, by branches of one great fault. These faults are in some places marked by a quartzose breccia, containing fragments of sandstone and other rocks. The vein of breccia varies in breadth; at the village of Kerjang, it is so largely developed that it forms a hill of considerable height. Between the branches of the fault Tálchír beds and metamorphics occur; north of all the faults metamorphics only are found.

The eastern part of the field from near Kerjang on the Tikaria river and Koukuraí on the Tengria to east of the Bramini is principally composed of Damúda rocks. These may usually be recognised by the occasional occurrence of blue and black shales, the latter carbonaceous and sometimes containing coal. The general section of the beds, so far as could be made out in a difficult country much obscured by surface clays and jungle, is as follows:—

1.—Interstratifications of blue and black shale, often very micaceous, with ironstone and coarse felspathic sandstone. These are at least 1,500 feet thick.

2.—Carbonaceous shale and coal, about 150 feet.

3.—Shales and coarse sandstones, the latter prevailing towards the base; thickness doubtful, but not less than 100 feet.

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* At the period when the Tálchír coal-field was examined, nothing whatever was known of the classification of rocks which has since been made out by the Geological Survey in the various coal-fields of India. Indeed, one of the very first and most important distinctions, that of the Tálchír group below the coal-bearing division, was made in this region, as already mentioned. The boundaries of the Máhádévás and Damúdas on the map in the Memoirs, Geological Survey of India is merely a rough approximation made from memory after quitting the field. The differences of the rocks had been noted in the field, but their area had not been mapped.

If this be correct, the coal only occurs upon one horizon. It is by no means impossible, however, that other beds may be found.

Coal is known to be exposed in three places. The most westwardly of these is at Patrapada in Ongúl, a village on the Medúlia Jor, a tributary of the Ouli river. Here some six feet of carbonaceous shale and coal are seen in the bank of the stream, capped by clay, upon which rest the coarse grits of the Máhádévá group. The area occupied by the beds is small.

The next place, which is far better known, is at Gopalprasad in Tálchír, on the Tengria river. The rocks at this spot are nearly horizontal for a long distance, and the coal bed extends for some miles along the banks of the stream above the village. It also recurs lower down the stream. The thickness of the bed is considerable, but its quality inferior, the greater portion being excessively shaley and impure. Selected specimens contain upwards of 30 per cent. of ash. It by no means follows, however, that better coal may not be found, and even the inferior fuel would be useful for many purposes if any local demand existed, and from the horizontality of the bed a large quantity might be procured with very little labour. The general dip in the neighbourhood is to the north, and any attempts at working the coal on a large scale, or further exploration by boring, should be made north of the Tengria stream.

The third locality is in a small nalla running into the Bramini from the west just north of the town of Tálchír. Beds lower than the coal are seen in the bank of the Bramini at the Rajah's residence; the carbonaceous shale with coal is exposed about 400 yards from the river in the small watercourse; only two or three feet are visible, the dip is north-west, and the coal is covered by micaceous, sandy and shaley beds. A boring north-west of this spot would test the bed fairly.

There is another locality in which, if the section can be trusted, beds just above the coal shales in position are exposed at the surface, and where, consequently, a boring might very possibly penetrate them. This is at the village of Konkurapal in Ongúl.* It is by no means certain that the Gopalprasad shales are close to the surface here, but the spot is the summit of an anticlinal, and some black shale seen in the stream resembles the uppermost portion of the rocks of Gopalprasad.

It is highly probable that closer search will show other places where coal is exposed at the surface.

The south-eastern part of the field consists of Tálchír beds, in which boulders are only occasionally found towards the base. They are numerous near the village of Porongo. Above the silt bed containing the boulders, there is a fine sandstone frequently containing grains of undecomposed felspar. There is no chance of coal being found in this portion of the basin, that is, south of a line drawn from east by north to west by south running about two miles south of Tálchír.

In several places in the Tálchír field iron is worked. The ore varies; sometimes the ironstones of the Damúda beds are used, but more frequently surface concretions, the supply of which is necessarily limited; sometimes the little pisolitic nodules of the laterite are found washed from their matrix and deposited in sufficient quantities in alluvial formations to be worth collecting. In one instance noticed, the ore was derived from the metamorphic rocks

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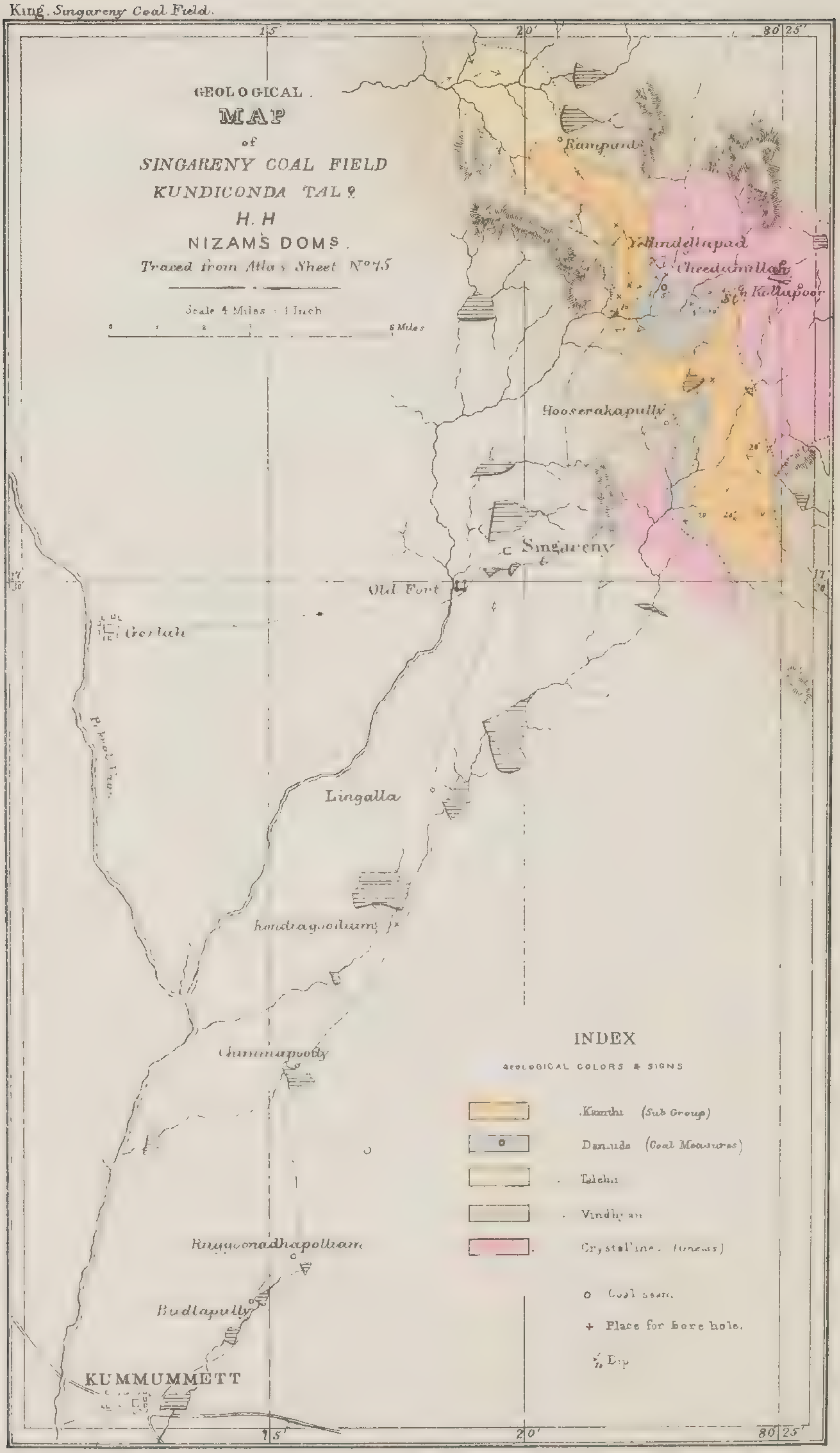
* Not *near* Ongúl (that is, not near the town so called,) as misprinted in Memoirs, Geological Survey of India, I, p. 61. The village is about 10 miles north-west of Gopalprasad.

Note.—The foregoing sketch of the Geology of Orissa was prepared for use in the proposed general Gazetteer of India, now in course of preparation, under the direction of W. W. Hunter, LL. D.


GEOLOGICAL
MAP
of
SINGARENY COAL FIELD
KUNDICONDA TAL?
H. H
NIZAMS DOMS.
Traced from Atlas Sheet No 75
Scale 4 Miles = 1 Inch
Rampaud
Yellindellapad
Cheedumillah
Kallapoor
Hooserakapully
Singareny
Old Fort
Lingalla
KUMMUMMETT
Budlapully
INDEX
GEOLOGICAL COLORS & SIGNS
Kamthi (Sub Group)
Damuda (Coal Measures)
Talchir
Vindhyan
Crystalline (Gneiss)
Coal seam.
+ Place for bore hole.
Dip

and brought from a distant locality ; it resembled the mixture of peroxide of iron and quartz found at the outcrop of metallic lodes and known as 'Gossan' in Cornwall. The method of smelting the iron in small furnaces is similar to that used in other parts of India, but the bellows employed are worked with the foot, a peculiarity only found in the south-western dependencies of Bengal and in Orissa. An account of the process with figures by my brother, Mr. H. F. Blanford, will be found in Dr. Percy's Metallurgy of Iron and Steel, p. 261.

The arenaceous ironstones of the Damúda group would, doubtless, yield a large supply of ore.

DENKINAL and HINDOLE.—These require scarcely any notice. So far as is known, they consist of metamorphic rocks, except the western extremity of the first named State which comprised the eastern end of the Tálchír basin. The metamorphic rocks are of the usual descriptions.

ATGARH.—The northern and western parts of this State consist of metamorphic rocks. Along the Mahanaddi from near Katák to the boundary of the state within three or four miles of the village of Tigeria, there is a belt four or five miles broad of the same "Katák" sandstones as are seen south of the Mahanaddi in the Púri district, being in fact a portion of the same basin. The rocks are precisely similar—coarse sandstones and conglomerates with one or more bands of white clay.

BANKI.—West of the sandstone area in the Púri district there is a broad expanse of alluvium running for a considerable distance to the southward from the Mahanaddi ; west of this again metamorphic rocks occur. There is a fine semicircle of detached hills running from Bankigarh to the village of Bydesar. The hills are partly of garnetiferous gneiss, partly of compact hornblendic gneiss. Banki Peak is of very quartzose gneiss. The strike varies in a peculiar manner, being very irregular, but with a general tendency in all the hills to dip towards the centre of the semicircle. South of the hills is a large undulating plain partly covered with laterite.

W. T. BLANFORD.

NOTES ON A NEW COAL-FIELD IN THE SOUTH-EASTERN PART OF THE HYDRABAD (DECCAN) TERRITORY, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

In the regular course of my work I have found a further small and hitherto unknown outlier of coal-bearing rocks, some thirty miles south-east of the Kamáram or Pangady Vagu field already described in these records.*

The present field is situated between about 17° 30′—17° 40′ north latitude, and 80° 18′—80° 25′ east longitude, near the villages of Rumpaid, Yellindallapad,† Hooserakapully, and Ragabonagoodium, in the eastern part of the Kundyconda talook. Its southern extremity is about four or five miles east of the large village of Singareny, and it may be as well to give this name to the field.

It is a narrow irregular patch of the 'plant-bearing series' of rocks, about eleven miles long and from one to two miles in width, giving an area of about nineteen square miles, though at the same time the coal measures are only supposably about eight square miles in extent.

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* Records, Geological Survey of India, Vol. V, Part 2, p. 46.

† Yellindallapad is nearest to the outcrop of coal seam ; but it is deserted at present (March 1872). Kollapoor and Cheedamulla (Sodamilla), a couple of miles to the east, are larger villages.

As the crow flies, it is about twenty-three miles north-north-east of the town of Khummumet,* and thirty-six miles east of Nellycudr, the tahsil village of Kundyconda talook.

As far as my knowledge goes, coal is only visible at one spot, and it is possibly only due to the fact of the country being so dried up this year, and the exceptional lowness of the water in the few stream pools, that I was able at last, after long and apparently hopeless searching, to find the upper edge of a seam showing just above the mud and water in one of these pools.† For this reason also is accountable the fact, that the people around had no idea of the existence of coal.

Even though the seam had not eventually been met with, I should have announced this as a possible coal-field, and recommended that it should be proved by boring, for the rocks were to my mind clearly of the coal-bearing series.

I am unable to give now the thickness of the seam, for neither time nor means for excavation were at my disposal; but there are two feet of coal ascertainable, and it looks a good strong decided seam.

The coal, so far, is tolerably light, compact, charged slightly with patches of powdery charcoal, is more or less bright, and breaks with a sub-conchoidal fracture. In an open fire, after being well dried in the sun, it burns brightly, though not quite so brightly as that of the Pangady Vagu field, and leaves a soft powdery ash.‡ A fair average specimen gives the following assay—

Fixed carbon	62·4
Volatile matter	22·6
(Moisture 6·0).	
Ash	15·0
	100·0

The specimen is however only from a few inches within the exposed surface of the seam.

Owing to the absence, or concealed state, of the outcrops of coal it is utterly impossible as yet to say what its extent may be, and this cannot be ascertained until borings have been put down in various parts of the field. The positions of the different series of rocks can only be indicated, as also the fact that there is coal.

A small map§ is appended, showing the general outline of the field and the rock series. Absolute correctness of boundary could not be attempted in this map; but the lines will be found sufficiently correct for future exploration.

This is essentially a field requiring examination by borings, which may be put down at some of the spots which are suggested on the map. In the Pangady Vagu field the outcrop of coal is so freely exposed that 'he who runs may read' it; but here, in the Singareny field, the mineral wealth is not at all so evident, though if it exist in any quantity, which I am inclined to think it does, it is to be got at and carried out infinitely easier in every way than at the Pangady Vagu.

* This name has been variously given, but the above seems the nearest adaptation to کهممت which is the official manner of spelling it. It is distinctly not *Kumarmet*; the spelling in the atlas map is very fair.

† It is possible therefore that the seam may not be visible to future explorers; but I showed it to two of the people of Kollapoor, who can easily point out the spot.

‡ In this, very different to the Pangady Vagu coal, the ash of which is hard and retains the form of the original fragments.

§ The southern extremity of the field is left undefined, as I am not quite sure that it does not extend further south. Lateness of the season and absence of water prevented my continuing the survey among the low hills in this direction.

Here, there is no hilly country to be got over, the locality being in the low country; while there is not nearly such thick jungle, though the field is completely covered by thin tree forest. The villages are somewhat more frequent and populous, and there are well marked paths in several directions. The distances also to the coal from Khummumet and Kundyconda are trifling when viewed in connexion with the proposed branch line* of Railway from Warrungul south-eastwards to the confines of the British Territory.

It is difficult to indicate the exact place of the coal outcrop, owing to the inability of obtaining a sight at any place through the jungle: but it is about two miles, or scarcely this, due west of the small hill station marked on the atlas Sheet 75, near the villages of Cheedamulla (Sodamilla) and Kollapoor, in the bed of the Yellindallapad vagu or stream. At this place, the stream is crossed by two low barriers of thick bedded sandstone striking nearly east to west with a dip of about 5° to the south, though the more northerly of the two barriers is part of a low anticlinal with the beds on its northern edge dipping north. The stream has cut an irregular zig-zag course, partly pot-hole and part gully, across this latter barrier, with rudely vertical sides of from four to thirteen feet high. The gully is deepest in the middle, deeper than at either the entrance or exit, and here the sandstones have been scoured out sufficiently to leave the top of the coal seam exposed all round the edges of an oblong pool, the floor of which is also of coal. It is thus that the thickness of the coal cannot be ascertained without boring or sinking a pit.

About two feet of coal are visible, and the seam is overlaid by, at the deepest part of the gully, thirteen feet of sandstone in one bed. There is no passage by shales, or clays, from coal to massive sandstone above, the junction between the two being perfectly clear and sharp. The rock is a coarse friable felspathic sandstone with small quartz pebbles, or gravel of pebbles thinly distributed through it. At the thickest, there is a single bed, but this eventually resolves itself into two or three thinner beds. This is the character of these sandstones on the Pangady Vagu as well as here; that they do not run of an even thickness for any distance, but that there are as it were bands of irregular lenticular beds of sandstone running into one another.

The general lie of the DÁMÚDÁ beds, as well as of the other associated rocks, is in easy undulations and from east to west, with somewhat of a general basin form; but they appear to be only exposed to any extent on the Yellindallapad Vagu. Over the rest of the field, if they exist, they are covered by sandstones of the *Kamthi* sub-group, though seldom to any great depth, possibly not exceeding two hundred feet at the most in the southern part of the field. In the northern half of the field, it does not appear as if any boring would have to exceed one hundred feet.

The rock series exposed in this Singareny field are, in descending order:—

Kamthi, sub-group.
DÁMÚDÁS (coal measures).
TALCHIRS.
VINDHYANS.
CRYSTALLINES (Gneiss, &c.),

Kamthis and DÁMÚDÁS rest directly on the GNEISS for a good part of the eastern edge of the field. No TALCHIRS are seen here, nor do I think they exist. Round the rest of the field, except for a mile or so to the east of Singareny, the underlying rocks are VINDHYAN.

* Part of a system of railway proposed by Mr. T. M. Hardy Johnston, M. Inst. C. E., Secretary to His Highness the Nizam's D. P. W., in a Memo. addressed to Sir Salar Jung Bahadur, G. C. S. I., dated July 1871.

The TALCHIRS are peculiar in occupying only the northern part of the field about Rumpaid, in the basin of whose main stream they are well seen forming good wide spreads of fine dirty yellowish green-grey (doe-skin-glove colored) mud sandstones. There are no signs of volcanic associations here, as is the case on the Pangady Vagu; nor is there any well-developed boulder bed. Here and there are occasional large pebbles or small assemblages of such; and in one spot in the bed of the stream from Mankarum, &c., which is joined by the Rumpaid stream, there is a huge block (now broken in half) of from 10 to 15 feet in diameter of VINDHYAN quartzite, which seems to be still almost *in situ.*

The TALCHIRS are distinctly overlapped by the next higher or coal-bearing series, and to such an extent both here and in the valley of the Godavery, that the two series would appear to be separated by a greater interval than mere unconformity of overlap would indicate. Otherwise, it is extremely difficult to my mind to account for such widely separated patches of a formation which always exhibits great uniformity of color and materials.

In the present field, I was not fortunate enough to find a section showing contact between the two series, but in my notes referring to the Pangady field the fact of unconformity is there stated. In that section, though a small one, the bottom sands of the BARAKARS are lying on bluntly-bevilled edges of mud sands of the TALCHIRS: the difference of angle being very little it is true, but there is still a difference.

It is to be remembered that the worn edges of the TALCHIRS (even now soft and friable mud-sands) would very likely, prior to the deposition of the BARAKARS, not be sharp and well defined, but rounded and somewhat fringed down; and the angle of dip not being much different from that of the newer rocks, their felspathic sandstones would, in general, lie over the sandy mud-stones more in the style of oblique lamination; and this is really somewhat the manner of the Pangady Vagu section, though there is, as I have written, the difference in lie of the *beds* themselves.

The DÁMÚDÁS and *Kamthis* are of the usual kinds, *viz.*:—coarse and fine felspathic sandstones, the *Kamthis* being coarser, more open textured, more ferruginous, and perhaps more gravelly. It is difficult, in the absence of any fossil evidence and favorable sections to draw any well defined boundary between these two series, though in general facies they are as distinct as possible, while at the same time they appear to be very distinct in age. It seemed to me that the passage between the two is marked by a set of thinner and somewhat closer-grained and compacter-brown sandstones coated on the surface with brown peroxide of iron, and that these are the lower beds of the *Kamthis.* On such a view, I have entered the two series in the accompanying map.

The hill station already referred to is of *Kamthis;* though, on the eastern side, and for some distance on the north and south, the base of the hill is of CRYSTALLINES. On the western side, one descends from coarse sandstones having a dip of about 10° west by north gradually to what are unmistakeable BARAKARS, but whether these are continuous right under the hill between the *Kamthis* and GNEISS, it is as yet impossible to say owing to the talus of debris all round.

From the hill there is a general easy undulation of BARAKAR sandstones nearly to the crossing of the Yellindallapad Vagu by the path from Singareny to the latter village; but just to the east of this path there are some low ridges of the compact ferruginous sandstones, which I take to be lower *Kamthis.* These are lying in a set of narrow undulations with a north—south strike; and at the crossing of the stream or *vagu* they are dipping east-south-east at from 20° to 30°.

The stratigraphic relations between the *Kamthis* and DÁMÚDÁS in this part of the country are also indicative of the latter being distinctly overlapped by the former; and that

the DÁMÚDÁS were either only deposited in small detached areas, or were largely denuded prior to the deposition of the *Kamthis.*

In the present case the beds of the hill station do not seem to be underlaid for the whole of this floor, but to have overlapped the DÁMÚDÁS to the eastward; and on this account it is to be feared that the *coal measures* will not be found constant throughout the field.

There are two other small outlying hill masses of *Kamthis,* a few miles to the north-east of the Singareny field, which are in general character exactly like the hill station, or of a steep-sided plateau form, and made up of nearly horizontal beds. One of these is above or immediately north of Dharmapooram; and the second further north-east between Kamaram and Anantarum. A couple of miles further east, is the south-western edge of the main area of *Kamthis.* Now, there are no signs of DÁMÚDÁS under this south-west edge; nor are there any under the second of the two outliers mentioned. There are, however, grey and pale buff sandstones at Dharmapooram underlying the hill of Kamthis, possibly Dámúdás, though I saw no trace of coal; and it might be as well to examine these rocks by boring.*

In the southern part of the field, the *Kamthis* are very strong, particularly on the eastern edge after the stream from the Kollapoor tank is crossed. Here they form some low ridges, and have a dip of 20° or 30° westward. The country is, however, so covered up by clay and sandy deposits and jungle that it is difficult to make out the lie from these ridges to the western edges of the field opposite Singareny; or to tell if any undulation brings DÁMÚDÁ beds up to within easy reach of the surface. Some of the beds on the western edge opposite Singareny in the valley of the stream from Kollapoor, &c., seemed to be DÁMÚDÁ sandstones. Borings should be put down right across this part of the field, and certainly; below the eastern slopes of the ridges on the eastern edge.

I have indicated in the map where it would be advisable to put down bore holes. In no case does it appear as if these would ever need to be sunk more than 200 feet at the utmost, and most of them, particularly in the middle of the field, would seldom exceed 50 feet. In all cases the borings ought to be sent down to the gneiss (the greater part of the floor of the field is possibly of crystalline rocks), except in the neighbourhood of Rumpaid, where Talchirs will be met with; or to the Vindhyans (hard quartzite, slates, and siliceous limestones) northwards from the Yellindallapad stream, or in the southern end of the field.

CAMP KHUMMUMET, 30*th March* 1872. WILLIAM KING.

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DR. CAYLEY.—Specimen of rough jade and of a rude stone mortar, small wooden wedges, &c., found in the abandoned jade quarries opposite Galbasha.

DR. WAAGEN.—A small rock specimen containing *Eozoon Bavaricum* from near Regensburg.

C. BERNARD, ESQ., C. P.—Left ramus of lower jaw of Bos (sp.?). Pranhita River above Sironcha.

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* The Geological Survey of India have no means of boring.

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CAPTAIN FRYER, Moulmein.—Seven specimens of sub-fossil crabs from river bank near Tavoy.

H. WOODWARD, ESQ., London.—A cast of *Eucladia Johnsoni*, H. W.

G. MAWE, ESQ., London.—A collection of fossils from the Kimmeridge clay.

THE ROYAL UNIVERSITY, CHRISTIANA.—A specimen of Sparagmit.

CAPTAIN FRYER, Sandoway.—A splendid collection of 33 ancient stone implements, some of great size and perfection, from Burmah.

" " A fine series of fossil crabs from river bank near Tavoy.

" " Specimens of limestone, Septaria, &c., from Sandoway.

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COCCHI IGINO.—Brevi Cenni sui Principali Instituti e Comitati Geologici e sul R. Comitato Geologico d' Italia, (1871,) 4to., Firenze.
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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1872. [August.

NOTE ON MASKAT AND MASSANDIM ON THE EAST COAST OF ARABIA, *by* W. T. BLANFORD, A. R. S. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The rocks of Maskat and of Rás Massandim, (the latter being the bold projecting cape which forms the Arabian side of the straits of Hormuz at the entrance to the Persian Gulf,) have already been described by Dr. Carter in his memoir on the geology of the south-east coast of Arabia; the former from personal inspection, the latter from specimens and a description furnished by Lieutenant Constable. In a recent voyage up the Persian Gulf, I had an opportunity of visiting both these localities, and the result of my brief examination of them, whilst entirely confirming Dr. Carter's account, enables me to add a few particulars of interest.

Maskat.—The cove of Maskat, as mentioned by Dr. Carter, is surrounded by dark coloured serpentine rocks rising steeply from the water. But here and there stratification or foliation is very apparent; thus, on the west side of the harbour, the rocks have a distinct dip to the north at an angle of about 45°. Riding inland from the suburb of Matrah to a distance of two or three miles, I found that the serpentine passes gradually into hornblende-schist,* and I can only suggest that the rocks of Maskat probably belong to the metamorphic series, which is mentioned by Carter as occurring in the form of granite, gneiss, diorite, &c., at several places on the south-east coast of Arabia.

Upon the schists and serpentine rest beds of pale-coloured limestone, with calcareous sandstones, conglomerate and variegated clays with gypsum, just as described by Carter. The conglomerate contains pebbles of limestone, sandstone, quartzite, and a green quartzose rock coloured by chlorite. Amongst the limestone pebbles, some of a very dark colour contain traces of fossils resembling encrinite stems; these are perhaps derived from rocks of the same series as those of Massandim.

I could find no fossils in the limestones, &c., at the place where I examined them, but their appearance is so similar to that of some of the nummulitic rocks of Sind that I should have classed them as probably nummulitic, even without the conclusive evidence furnished by Captain Newbold.† At the same time it struck me that some greyish overlying beds which I had not time to visit, but which are well seen on the coast north-west of Maskat, might belong to the newer tertiaries of the Makrán group.‡ The little island of Fahil appears to be of nummulitic limestone.

Massandim.—The whole of the promontory which, jutting out from the Arabian Coast, closes in the southern portion of the Persian Gulf appears to consist of stratified dark-

* It is doubtless a less schistose form of this rock which Dr. Carter calls diorite.

† Jour. Bombay Br. R. A. S., Vol. III, pt. 1, p. 27.

‡ See previous paper, p. 43, for the meaning of this term.

coloured limestone. I had an opportunity from the deck of the steamer of seeing the cape itself and the little island of Massandim, from which the whole promontory derives the name by which it is chiefly known.

Subsequently in Khor-as-Shem, or Elphinstone Inlet of the old charts, formerly a telegraph station of the Persian Gulf Cable, I was enabled to examine the rocks more closely.

They consist of black, brown, dark-grey, and dark-buff limestone, hard, compact, and intersected by veins of calcite, with a few comparatively thin and subordinate beds of shale and sandstone. These rocks are distinctly stratified, the slight variations in the colouring of the different beds rendering the stratification distinct up to the very summit of the huge precipitous mountains which rise from the shores of the inlet. As a rule, the beds roll about with a moderate dip not exceeding 20°; in places there is much disturbance and contortion. The thickness of the beds must be very great; some of the mountains on the inlet are said to be 6,000 feet high, and they evidently consist entirely of the dark limestone; indeed no trace of any other rock was to be seen in the neighbourhood.

Fossils are far from scarce in the limestone, but it is unusually difficult to find any in a state in which they can be recognised. Sections of shells, both univalves and bivalves, fragments of corals, and apparently of encrinites, are to be found in several beds, but it was only after much search that I found anything which may possibly be identified.

These fossils have been submitted to careful examination by Dr. F. Stoliczka, Palæontologist to the Geological Survey of India, who states: "The limestone contains several specimens of a *Myophoria*, externally very closely resembling *M. chenopus*, Laube, from the St. Cassian beds, and indicating upper triassic strata. This is the only fossil which can be even approximately determined. It occurs socially, and together with some casts of *Gastropoda*, resembling *Chemnitzia*.

"A few casts of a Pelecypod resemble in shape *Anoplophora*, also a triassic genus. There are two valves of an *Exogyra* of the shape of the neocomien *E. conica*. As far as I know, this type is unknown in the Trias.

"A few fragments of a Pecten, undeterminable, occur; and several fragments of an Asteroid coral."

I suspect that this great limestone-formation must occupy a considerable area in 'Omán; and it is far from improbable that it forms part of the great dark-coloured mountain ranges behind Maskat. This is the more probable, because Dr. Carter obtained through Mr. Cole of the Indian Navy specimens of similar limestone from the mountains near Rás-el-Had.

The most remarkable circumstance about the Massandim promontory is its form. The inlet I visited, Khor-as-Shem, runs from the Persian Gulf for, I believe, seventeen miles into the heart of the hills; it is about 17 to 20 fathoms deep throughout, and in many places even close up to the rocks on each side. It is only separated by a belt of land less than a mile broad from another inlet called Ghubet Ghúzirah (Malcolm's Inlet of the old charts), which enters from the eastern side of the promontory in the Gulf of 'Omán, and which is still deeper. Other inlets occur, all very deep, and immediately off the rocky coast is the deepest part of the Persian Gulf. There is a curious resemblance of these inlets to the fiords of Norway, but the latter are undoubtedly of glacial origin, whilst no such cause can be suggested in one of the very hottest regions of the whole surface of the globe. The sea could never excavate such land-locked basins as that of Khor-as-Shem, barely a mile across in places and 20 fathoms deep. I can only suppose that the peculiar form of this coast is the result of subsidence, that the inlets were valleys on the land produced in the usual manner by rain and streams and then sunk beneath the sea. The great depth of the Gulf of 'Oman

off Maskat (2,000 fathoms) may point to a general and long continued subsidence along this coast, and, if so, it is curious to contrast it with the evidence of comparatively recent elevation on the opposite shores of Persia as noticed in a previous paper.

CAMP GWADAR, BILUCHISTAN;
January, 1872.

AN EXAMPLE OF LOCAL JOINTING, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Within the cantonments of Jabalpúr, south of the civil station and of the city, there is a small group of hillocks, or steep bare rock-masses, about fifty feet in height. The whole stand within an area of nearly one hundred and fifty acres, of which the protruding rock occupies about two-thirds, in three principal masses. They are locally known as the Kattungá quarries; the sandstone being much valued and extensively worked for building stone. Its use for this purpose is greatly facilitated by the very perfect jointing by which the rock is traversed. The unique character of this feature in the great formation to which the sandstone belongs, and the peculiar petrographical circumstances of the rock in this locality, give some interest to the case as suggesting definite conditions to which the jointing is due. There is nothing new in the main cause thus educed, but so well-marked an instance of local action, or of secondary influences, may be worth recording.

The sandstone belongs to an upper member of a great series of rocks representing a well-defined period in the geology of India, beginning with the glacial deposits of the Talchír group, upon which rest the coal-measures, and ending with various groups hitherto included under the name Máhádévá. These strata, as a whole, are but partially indurated and only slightly disturbed. Jabalpúr stands upon a boundary of the formation running continuously for 350 miles in an east-30°-north direction, along the valleys of the Narbadá and the Són. In this neighbourhood the massive sandstones, irregularly associated with pale shaly clays, are even softer than usual, weathering with well rounded outcrops and an undulating surface. It is difficult at first sight to believe that the sharply edged, cliffed rocks of the Kattungá hillocks can belong to the same formation. Looked at from the north-north-west or the south-south-east they would be taken for well-bedded vertical quartzites.

In the annexed diagram (Fig. 1) a number (56) of observed bearings of the joint-planes are tabulated. Excluding only seven bearings, all in the north-east quadrant, the remainder

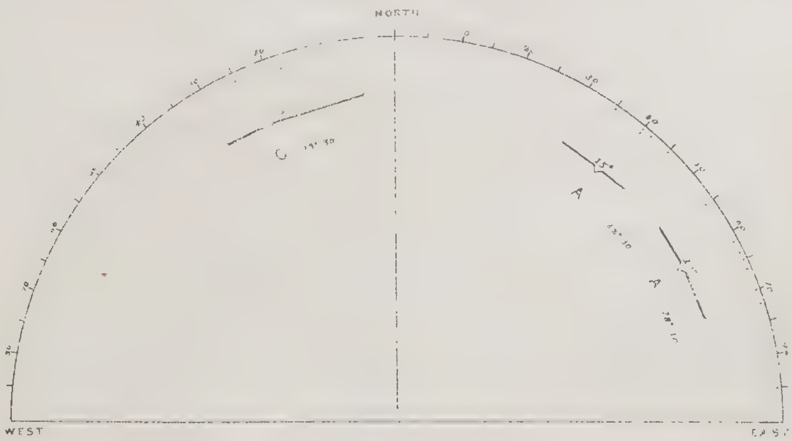

Fig. 1.—Diagram showing bearings of joints in the sandstone of Kattungá, Jabalpúr.

can be distributed into three groups. The numbers of observations in the two quadrants respectively do not at all represent the relative importance of the groups. The group C predominates greatly, dividing the whole rock-mass into cleanly separated vertical layers of from six inches to three and four feet in thickness. About an equal number of the cross-joints in the north-east quadrant were taken in order to obtain fair averages of their bearings among themselves. These cross-joints are much less regular than the main joints, often leaving unbroken spaces of thirty and forty feet: the planes, too, are less continuous, and frequently have a considerable underlie.

It will be seen from the table that the three groups present a very satisfactory illustration of Professor Haughton's explanation of joint-systems,* which assigns definite mechanical relations between the directions of the joint-planes traversing any mass of strata and those of the compressing forces that have affected them. The Primary system, generally the predominating one, following Sharpe's law of cleavage, occurs at right angles to the main compressing force. The second system is determined at right angles to the Primary, and therefore at right angles to the direction of least compression, from which relation to the Primary it is called the Conjugate system. Other four systems, (respectively conjugate to each other) may be determined, related to the two main systems by the limiting angle of friction of the rock. There is no difficulty, for the case under notice, in assigning the direction of the compressing forces by which the rocks have been affected, and thus obtaining the key to the induced rock-structure. Although, as a whole, these formations lie in their original position of deposition, there are many instances of even intense disturbance near the boundaries of the basin, where much of the compressing forces seems to have been expended, the yielding masses of the newer sedimentary deposits being here in contact with highly consolidated metamorphic rocks. The flexures of the strata thus produced observe a very general parallelism to these boundaries. As already mentioned, the boundary upon which Jabalpúr is situated has a very steady general bearing of about east-30°-north. In this immediate neighbourhood there is a single case of disturbance, and it conforms to the rule just indicated: at about half a mile to the south-east of the quarries there is a ridge formed of strata of the same formation dipping at 30° to south-35°-east. The direction of the compressing force being thus fixed, it is evident that the A group of joints, at right angles to that direction, represents very closely the Primary system; its mean bearing being 28°30′ north of east. The group C, which is here the dominant one, then takes its place as the Conjugate system to A. Its mean range in the diagram is 23° 30′ west of north, giving only 85° between it and A; but this might evidently be brought much nearer to the normal by slightly limiting the range of the group to where the readings are concentrated. The group A would come in as a Secondary system to A¹, the angle between them being 22° 30′. Interpreted from this point of view, it would seem that the direction of the main joints C was determined at right angles to that of least compression.

What it is chiefly desired to exhibit in this example is the conditions which seem to have produced so very local a peculiarity. It may, I think, be presumed that the power concerned was the shrinkage upon induration—a familiar agency in such phenomena; but it seems to have been seconded in an essential manner by local conditions, such as the texture, the homogeneity, the thickness, of these masses, or by their position upon a more rigid base. These determining secondary causes are, at least, suggested by the comparison of the Kattungá locality with others in the neighbourhood, where the induration is quite as great without similar jointing. Several such cases may be seen on the open ground to the east of the station, where there are a few scattered rocky hillocks, of about an acre in extent, formed of hard sandstone of the same age as the Kattungá rock, but without regular jointing.

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* Phil. Trans. for 1858 and 1864.

The Kattungá sandstone is of moderately coarse texture. Although the stone is firm, the binding ingredient is in small proportion; there is a sprinkling of white clay, but not sufficient to fill the interstices of the grains; the stone thus remains a freestone, dressing well under the chisel. From a cursory examination made by Mr. Tween, the cement would seem to be a slight infusion of silica; it is unaffected by ordinary solvents. The stone of the other hills is somewhat finer in grain, with a full proportion of matrix, which, under the indurating action, assumes a porcellanic state. This highest induration seems confined to the parts along the few irregular joints that occur, but in the interior of the rough masses the stone is still quite as hard as that of Kattungá.

From top to base of the Kattungá hills there is no sign of bedding. The lamination is, however, betrayed by slight variations in texture, showing the original lie of the rock and its undisturbed horizontality. There is no such massive bedding in the sandstone of the other hills; even shaly partings are not unfrequent.

Such differences of texture, structure, and homogeneity might go far to explain the exceptional feature in the Kattungá rock; but there is a peculiarity in its position that is worthy of notice in this connection. The main area of the formation lies to the south-south-east; and in the low ground to the north of the quarries the soft sandstones and shales are again found in well-sections under the alluvium; but at a short distance to the west there is a range of granite-hills, on the continuation of which, prolongations and inliers of the granite weather out for some distance in the low ground close to the south of the quarry-hills. Thus it seems highly probable that the sandstone here is throughout underlaid almost immediately by the granite. At one spot this is fully seen, where a small promontory of sandstone crosses to the west of the city-branch of the Nágpúr road, and rests upon a knoll of granite. Directly coating the uneven surface of the granite there is here seen a variable bed of coarse arkose, now in a rusty and friable state; its surface is conglomeritic. Upon this rests a two-feet bed of a very peculiar rock—a coarse mixed sandstone with an excess of earthy matrix in a highly indurated, porcellanic, condition; the whole shivered into most irregular blocks. This same quartzite is very extensively found along the base of the formation as a contact-rock; but it also occurs near the boundary between soft earthy beds. In the section under notice it is immediately overlaid by a remnant, some fifteen feet thick, of the highly jointed sandstone. The hard but unjointed sandstone of the other localities rests upon a considerable thickness of the unconsolidated sedimentaries. May it not be that the shrinkage in the latter cases was satisfied to some extent by external yielding; whereas in the Kattungá rock it had all to be accounted for within the mass?

Although there is much reason to believe that the directions of these joint-systems were determined in accordance with the law expounded by Professor Haughton, it is necessary to suppose that even the Primary joints were here developed from a latent state by the same conditions that produced the main jointing, the compressing force not having been sufficient directly to complete this cleavage-jointing.

20th May, 1872. H. B. MEDLICOTT.

A FEW ADDITIONAL REMARKS ON THE AXIAL GROUP OF WESTERN PROME, *by* W. THEOBALD, ESQ., *Geological Survey of India.*

Since the publication of my remarks on the axial group of Western Prome, in the Records of the Geological Survey, No. 2, 1871, the more extended examination of the neighbouring country has made it necessary to restrict the group within somewhat narrower limits than I had at first assigned to it; and I think I shall best convey an idea of the extent and scope of such limitation by briefly sketching the various steps by which our knowledge of these beds has been acquired.

In 1861, Mr. W. T. Blanford, who was then entrusted with the survey of Pegu, expressed an opinion, founded on the examination of the Bassein district, that the altered, or "Hill rocks" as he termed them from their being confined to the hilly region wherein the Arakan range here becomes merged, were as likely as not altered Nummulitic strata, notwithstanding the gene al difference in character between these "Hill-rocks" and the unaltered Nummulitics met with in the plains and outer hills; though this view could not be corroborated by fossil evidence, as no fossils had then been detected in these "Hill-rocks."

A few years later I visited a portion of the ground surveyed by Mr. Blanford; the result being that I found myself unable cordially to assent to the above view of Mr. Blanford, and preferred to allow the point to remain an open one in the hope of some evidence of a more positive kind regarding the relation of the altered and unaltered rocks of Pegu being forthcoming in time elsewhere. About this time, my colleague, Mr. F. Fedden, who was then working with me in Pegu, discovered some dark shales containing Foraminifera, (*Operculina*) in a small stream, on the western side of the Arakan range, falling into the Gwa river, and this, with one more recently discovered, which I shall notice presently, is the only instance with which I am acquainted of fossils having been detected well within the area of the "Hill-rocks."* The isolated occurrence, however, of a few fossils, even the most characteristic, at a single spot would not have been conclusive as regarded the age of the group constituting the great mass of the Arakan hills; and little or no progress was therefore made towards the solution of the question of identity or not of the altered and unaltered rocks of the Arakan range up to the time of my writing my remarks on the axial group in the Records of 1871. When, therefore, I commenced work on the frontier in the season of 1869-70 among the "Axials" as restricted by me, which are here so well displayed, and in such contrast to the Nummulitic group of the plains, I recognised, as I thought, a confirmation of the view to which I had always inclined—namely, the distinctness, geologically speaking, of the altered and unaltered rocks which had proved so puzzling in Bassein—and in commencing to follow up south the boundary of the Axial group and the Nummulitics, I not unreasonably supposed that I was holding the clue to the true relations of the rocks in Bassein. At first of course all went satisfactorily enough, the nature of the ground considered, for I was dealing with a veritable geological boundary; but I had not got well out of the Prome district when I began to feel less satisfied with my work. It may be remembered that I described the upper or typical Axials as resting on a series of shales and sandstones which possessed much of the general aspect of the Hill-rocks met with to the south; and I somewhat hastily, though with a great show of probability, concluded that they belonged to the same group, and that the fault, which, as I believed, brought in the upper Axials against the nummulitic strata in Prome, continued on and brought up the lower Axials in like manner to the south. By the time, however, I had reached the confines of the Bassein district, I became convinced that the boundary I was then following was illusory, that is, not a geological one, but merely one dividing the altered from the unaltered side of the same group, and which was becoming more and more vague towards the south, where, as Mr. Blanford had originally remarked, no separation was possible between these often dissimilar but really geologically identical groups. Although I am now convinced in my own mind of the correctness of the view originally put forward by Mr. Blanford, I deemed it highly desirable, if possible, to procure some corroborative evidence. I had, it is true, failed to detect any fossils in any limestone I had yet examined within the area of the Hill-rocks; and this, coupled with the fact of nummulites being plentiful in many places among the unaltered beds, had much tended to strengthen my doubts of the view I was at length forced to adopt, but I determined to visit one spot where Mr. Blanford has marked limestone on the Pyennea Choung, ten miles west

* The Banmi limestone contains corals and other fossils, but in a state that renders it doubtful if they can be satisfactorily made out.

of the Bassein river, within the area of the Hill-rocks. At first this limestone seemed as devoid of fossils as most of the similar outcrops of the rock within the hills examined by me, but in one place I was rewarded by finding numerous small nummulites in it, which seemed to have escaped the molecular action, which, I presume, is the true cause for the general disappearance of fossils in the rock, and not its originally azoic character. Having thus satisfied myself that the "Hill-rocks" of Blanford comprising the southern portion of the Arakan range were of Nummulitic age, and consequently distinct from the Axials of the Prome district, it became necessary to retrace my steps in order to discover where, in following down the line of altered rocks, I had, as it were, got shunted off the Axials on to the Nummulitics. This point was very soon ascertained. The upper Axials, which are so well displayed on the frontier, hold their course continuously to within a short distance of the Thanni Choung, a distance of forty-seven miles as the crow flies, from where they enter British territory, or a little above the parallel of Prome. A few rolled lumps of the characteristic grits of the upper Axials may be seen in the Thanni Choung, below the junction of a small stream, (the Thaybew Choung, not on map); but nowhere else can any evidence of the presence of this group be detected in the Thanni Choung, either above or below this spot. The upper Axials indeed stop here abruptly; for, a very short distance up the Thaybew Choung the characteristic axial limestone comes in, from which I obtained numerous specimens of an echinoderm, unfortunately none of them in a state for identification. Thus far the boundary of the group is, I believe, a faulted one, but here the fault would seem to die out and the group to be covered up by the altered Hill-rocks of Nummulitic age. The rocks actually seen in the Thanni Choung do not give much assistance towards determining the question of their age. Just below the junction of the Thaybew Choung the shales are seen which may confidently be referred to the Nummulitic group. Above the junction of the Thaybew Choung great disturbance and alteration of the beds is seen; harsh indurated sandstones, vertical and much shattered and disturbed, occur, and above this spot, sandstones and shales of the ordinary kind met with among the Hill-rocks. Now, for any direct evidence to the contrary, these might belong to either group; and their position is quite such as would identify them with the group of similar character underlying the upper or typical Axials. Thirty miles south of this is the village of Chin-na-gyee, where, in my note on the Axials, I thus described the boundary which I then supposed was the junction of the two groups, and the continuation of that which in reality stops short of, and without crossing, the Thanni Choung. "The stream above Chin-na-gyee seems to display mostly shales of the lower group, and just south of the village in the bed of the stream, highly altered sandstones come in of the usual harsh character of so many beds belonging to this portion of the group. Not thirty yards below them comes in, quite unaltered, a calcareous sandstone profusely charged with nummulites. The *boundary* is here fixed within a few yards, and strikes through the centre of Chin-na-gyee village, and at this point would seem to completely cut out the whole upper group" (of Axials). This section is merely a better and more sharply defined one than usual of the ordinary junction of the altered or Hill-rocks with the unaltered Nummulitics; and at the time I first visited it, I had no doubt of its being the faulted boundary of the two groups (Axials and Nummulitics), instead of merely the boundary of that peculiar metamorphism which characterises the Hill-rocks, and which, the further we go south, seems more and more capriciously and irregularly developed. Of the lower Axials, now that all the Hill-rocks to the south are separated from them, we know very little. The country occupied by them being, without any figure of speech, most impracticable. From the point near the Thanni Choung, where the group terminates, the boundary recedes to the westward along the watershed separating the Thanni Choung from the Muday Choung to the north. This is indicated in the map by a dividing range, which gives a very inaccurate conception of the physical aspect of the country, though it may, very probably, correctly enough mark the actual watershed. Nattoung, a conical hill capped

with serpentine, is situated between the Thanni and Muday streams, at almost the extremity of the axial area. It is steeply scarped on three sides, but is accessible on the north-north-east by a steep spur. From the summit a fine view is obtained of the ground intervening between it and the main Yomah range, but which being intersected by no considerable stream, totally uninhabited and covered with virgin forest, is quite impossible to explore; and it is not till the western side of the Arakan range and the Akyab district comes under survey that more details of the Axial group can be looked for; and even then the difficulties presented by the wild, forest-clad and uninhabited nature of the country in question will for many years act as a complete bar to anything like a full and satisfactory examination of the ground. It is beyond the aim of my present note to enter on the relations, as far as known, of the Axial group to the westward, and I will content myself with a brief recapitulation of the main points now established.

1st.—The Axial group extends down into Pegu, a distance of about forty-seven miles from the frontier; the boundary on the eastern or Pegu side of the Arakan range being a faulted one, having a strong upthrow to the west, whereby the upper Axials are brought into contact with the Nummulitic group.

2nd.—There is no evidence that any portion of this group passes south of the Thanni Choung, though the precise boundary between the lower Axials and the "Hill-rocks" or altered Nummulitics is obscure and at present only provisionally determined.

3rd.—On the western side of the range, a great thickness of beds intervenes between the Axial group and the Nummulitics, amongst which the presence of cretaceous rocks is shown by the occurrence of *Ammonites rostratus*, Sow., near Maie. These cretaceous strata certainly extend as far south as Kaintali, but being in the province of Arakan, have only received a very cursory examination.

May, 1872.

SKETCH OF THE GEOLOGY OF THE BOMBAY PRESIDENCY, *by* WILLIAM T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey of India.*

The Bombay Presidency consists geologically, as well as physically, of two parts. The north-western of these consists of Sind, Kachh and Gújrát; the south-western comprises the Marátha country. Roughly the river Narbadá (Nerbudda) may be said to divide the two regions. A part of the distinction is climatic, the north-eastern division being, to a great extent, beyond the area of the periodical monsoon rains, but the essential differences are due to the very dissimilar geological formations of which the two regions consist.

The geology of the Marátha country is for the most part of the simplest kind, by far the greater portion of the surface being composed of nearly horizontal strata of basalt and similar rocks. Hence the peculiar features of the country, the extensive plateaus, the long hog-backed hills, the terraces on their sides, and the black precipices which in so many places almost cut off communication with the low ground. Hence also the fertility of the soil which covers the country, and its adaptation to the growth of cereals, pulse, and cotton; and to the same cause may be attributed the thinness and stunted growth of the forests except in a few favoured localities.

The rocks of the Bombay-Deccan are precisely similar to those of neighbouring portions of the Indian peninsula.* India proper in its geology stands as strikingly aloof from neighbouring portions of Asia as it does in its ethnology and zoology. But the rocks of Gújrát, Kachh and Sind, are only partially represented in the Indian peninsula, and must rather be considered as

* By India I mean the country of the Hindu races. To call Burma, the Malay peninsula, Siam and Cochin China, and, still worse, Java, Sumatra, and Borneo, India appears to me a scientific blunder. The countries have no geographical, geological, ethnological, nor zoological connection with India proper.

belonging to Continental Asia, being continuous, as was long since shown by Dr. Carter, with the formations found in Persia and Arabia. To the northward the Sind rocks extend to the foot of the Himálayas.

To this striking change in the geology is due to no small extent the difference in the physical features of the countries north-west of Gújrát. Instead of plateaus covered by black soil, we find undulating sandy plains with scattered craggy hills; the immense alluvial flats to the north of Kachh and Gújrát are for the most part deserts of blown sand, and the fertile country consists of a belt, rapidly diminishing in breadth to the westward, along the borders of the sea; its verdure is due to the humidity caused by the neighbouring ocean. In Sind even this ceases, and the country, except on the banks of the Indus, or where reclaimed by irrigation, is an arid tract of gravel and sand from which arise the steep scarps of limestone ranges.

In the ensuing brief description of the different groups of rocks found in the Bombay Presidency, it will be seen that each system is mainly developed in one or the other of these two great divisions. The only important exception is in the metamorphic rocks at the base of the whole geological series. The basaltic traps extend into Káttiáwár and Kachh, but they occupy but a small area. The division of course is not absolute, but it is evident that, as has been suggested by Professor Huxley, the Indian peninsula has had, during the later geological epochs, a different history from the country to the north-west. In the following list of formations the Indian classification has been adopted, partly in order to show the relations of the various beds of Sind and Kachh to those of the Indian peninsula, partly because the usual European classification is quite inapplicable to the latter; for it is as yet a moot point whether the great Deccan trappean series is secondary or tertiary, and the European equivalents of the Vindhyan series are unknown with any accuracy.

The following is a list of the formations found in the Bombay Presidency and its dependencies in descending order :—

VI.—Later tertiary and recent ...	1. Black soil.
	2. Littoral concrete.
	3. Alluvium of Sind, Kachh, and Gújrát.
	4. Laterite of the Konkan.
	5. Surface gravels of Sind.
	6. Ossiferous gravels of river valleys.
	7. Upper tertiaries of Káttiáwár and Kachh.
V.—Older tertiary or nummulitic series.	1. Older tertiaries of Súrat, Bharoch, Káttiáwár, Kachh, and Sind.
	2. Perim Island bone beds.
	3. Laterite of the Deccan.
IV.—Deccan series ...	1. Deccan traps.
	2. Intertrappean beds of Bombay.
	3. Ditto of Dewad, Nágpúr, Narbadá valley, &c.
	4. Cretaceous beds of Bágh.
III.—Oolitic series ...	1. Jurassic rocks of Kachh: upper.
	2. Ditto ditto : lower.
II.—Vindhyan series ...	1. "Diamond limestone" and sandstone of Belgáon, Kaladghi, and Ratnagiri.
I.—Submetamorphic and metamorphic.	1. Champanír beds.
	2. Granite, gneiss, mica schist, &c.

These are all which are actually known to occur in the area to which the present notice relates and its immediate vicinity; but in order to explain them, it will be needful occasionally

to make brief reference to strata found in adjoining districts. In proceeding to give a brief description of these various formations and of their distribution in the Bombay Presidency, I shall, as is customary and most convenient, commence with the oldest.

I.—METAMORPHIC AND SUBMETAMORPHIC SERIES.

1. *Metamorphic rocks.*—Under this heading are classed together all the crystalline formations, *granite, syenite, diorite, &c., gneiss, hornblende-schist, mica-schist, quartzite, crystalline limestone, &c.*, whether laminated or not. It is possible that veins of granite, syenite, and diorite may exist of later date than the metamorphism of the gneiss, but none have been met with as yet of which the later origin can be proved; and the majority of such veins are clearly contemporaneous with the metamorphic action, whilst throughout India wherever extensive areas of granite have been examined with care, the rock has been found to pass gradually into gneiss or schist on its edges, or here and there throughout the tract of country composed of it. The only exceptions to the rule of the apparent contemporaneity of the granite and gneiss are in the granitic masses found associated with submetamorphic rocks in places. But the relations of these submetamorphic rocks themselves to the gneiss and its associates are far from clear.

Veins and irregular masses of greenstone (diorite) are similarly found passing into hornblendic gneiss. There are, however, in places trap dykes of later age contemporaneous with the Deccan traps or other outbursts; but many of the dykes which intersect the crystalline rocks are evidently of very old date, because they do not penetrate the superjacent strata.

It is quite possible that several series of rocks of widely differing ages are included in the metamorphic formations of India, and Mr. H. B. Medlicott has pointed out some facts in favor of such a division amongst the crystalline rocks of Bengal.* But until these have been traced out more completely than has hitherto been practicable, it is necessary to class all together.

Metamorphic rocks cover a much smaller area in the Bombay Presidency than they do in most other parts of India. None are known to occur in Sind or Kachh, but north of the Ran of Kachh, they are seen at Nagar Parkar, and thence stretch to the eastward towards mount Abú, which is composed of them. They occupy a large tract in northern Káttiáwár, including Girnár hill, which is their southern limit; they are also found close to Palitána and in the neighbourhood of Gogo, but the detailed geology of this country and of the regions to the north is very imperfectly known. East of the great alluvial flat which extends northward from the Gulf of Khambayát (Cambay) metamorphic rocks of a highly granitic character occupy the country about Idar, and occur throughout a considerable tract around Godoa and Chota Udepúr in the Rewa Kanta, but they are covered up by sandstone and trap to the south, and nowhere in this direction reach the river Narbadá, whilst east of Baroda, near Champanír, they are replaced by the other rocks to be presently described.

From the Narbadá to the southward metamorphic formations are unknown† within the limits of the Bombay Presidency until the southernmost districts are reached, in which they again appear, and they occupy nearly the whole western portion of the Indian peninsula from this limit to Cape Comorin. On the coast they emerge from beneath the higher formations just north of Málwán, and nearly the whole of Sawantwadi, the Goa territory, and North Kanara is composed of them, their surface being frequently concealed by thick deposits of laterite. In the high table-land east of the ghâts, the southern part of Belgáon, the south-eastern corner of Kaladghi, and nearly the whole of Dhárwár consists of these formations.

* Records, Geological Survey of India, Vol. II, p. 40.

† In Greenough's geological map of India granite is represented as occurring in three places in the trap area of the Deccan. These places are close to Elúra (Aurangabad), Satara, and Kolhápúr respectively. It appears doubtful whether these granitic inliers really exist. There is one small patch close to Phonda in the Konkan, twenty-five miles south-west of Kolhápur, but this is far from the position indicated by Greenough.

SUBMETAMORPHICS—CHAMPANÍR BEDS.

The classification of such Indian rocks as are distinguished from the gneiss and its associated formations by partial or total absence of metamorphism, and yet are of greater age than the Vindhyan series, is extremely imperfect. It is uncertain how far the various local groups represent each other, and to what extent any or all of them are the less altered of the true metamorphic rocks.

The only known occurrence of these submetamorphic rocks within the Bombay area is near the ruined town of Champanír at the foot of Pawágarh hill, east of Baroda. These beds occupy an area stretching for about twenty miles east from the hill (which is of trap) and for a considerable but unknown distance to the north. The principal constituent formations are quartzites or rocks intermediate between quartzite and sandstone conglomerates: slates and limestones also occur in considerable quantities, and ferruginous bands, some of them chiefly consisting of magnetic iron ore, occasionally. The limestone is sometimes quite unaltered, but in places it is highly crystalline, and at one spot near the village of Kadwal, it contains fine crystals of actinolite. The most characteristic beds are perhaps the conglomerates, the matrix of which is a coarse sandstone, containing pebbles and rounded blocks of granite, quartzite, talcose slate and crystalline limestone, some of which, especially those of limestone, have a diameter of a foot or more. All the finer argillaceous beds exhibit cleavage, and some of the slate is so fissile that it might probably be employed for roofing purposes. On their southern boundary these beds appear to pass by gradual transition into the true metamorphics.

The relations of the Champanír group, as these beds have been provisionally named, to the other submetamorphic beds, remain hitherto somewhat obscure, but they are perhaps the representatives of the Gwalior series (see Records, Geological Survey of India, Vol. III, p. 33). From the Bijáwar rocks of Bandélkhand and the Narbadá valley they differ much in mineral character.

II.—VINDHYAN SERIES.

The rocks to which the general term Vindhyan has been applied from their extensive development in the Vindhyan plateau north of the Narbadá consist of sandstones (occasionally so hard as to assume a semi-vitreous appearance and to approach quartzite in character), limestones and shales, and are very often distinguished by a more or less pink or purplish colour, less frequently seen in the limestones than in the other rocks of the series. These beds are separated by a well-marked geological break, the evidence of which is found in extensive unconformity, from all the earlier formations. They are divided into two principal groups, an upper and lower one, the former of which, comprising the typical Tárá sandstone, Kattrá shales, and Panná sandstone of Dr. Carter, and the Bhánrer, Rewá, and Kaimur groups of the Geological Survey classification, occupies an immense tract in Málwá and Bandélkhand, whilst the latter is only found here and there upon its borders. Very large areas in the Máhánadi, Godávari, Krishná, and Pennér vallies are occupied by sandstones and sandstone-quartzites, limestones and shales closely resembling the Bandélkhand rocks in mineral character, but more nearly allied to the lower than to the upper sub-division. They are identical with the diamond-sandstone and limestone of the earlier Indian geologists,* and were included by Dr. Carter in his Oolitic series, together with the important formations hereafter to be mentioned. Unfortunately, no well authenticated fossil, animal or vegetable, has hitherto been obtained from these beds, the few supposed organic remains which have been recorded as occurring in them being either of a very doubtful nature or else derived from strata of later date. The geological age of the

* The diamond sandstone, however, as described by Voysey and Malcolmson, comprised formations which have now been ascertained to belong to a series of much more recent date than the Vindhyans.

Vindhyans is therefore obscure, all that can be safely asserted being that they cannot be more recent than the middle palæozoic rocks of Europe, whilst they may be considerably more ancient.

The Bandélkhand Vindhyan area is entirely outside of the Bombay Presidency, its south-western corner being at Barwai in the Narbadá valley, but the representatives of the same series in the Krishná valley and its vicinity occupy a well marked belt, locally of considerable width in the southern part of the Presidency, intervening between the trap and the metamorphic rocks. These beds appear on the west coast at Ochrá, a little north of Málwán. They are well seen at the foot of the Phonda ghât, and consist of hardened sandstone approaching quartzite, white, yellow, or pink in colour, and shales. The surface is very uneven, and had evidently suffered greatly from denudation of an irregular kind before it was covered by trap; hence their distribution at the base of the volcanic series is very irregular.

Above the ghâts the quartzites reappear in the south of the Kolápúr territory, and extend eastwards in a band of very variable width across the southern parts of the Belgáon and Kaladghi districts into the Nizam's dominions.

On its northern side this belt of country is bounded in most parts by the extremely ragged southern edge of the Deccan trap-area. To the south it is bounded for some distance by the trap, but after that by the northern edge of the great gneiss-area of Madras. A little east of where these rocks cross the Krishná river, thirty miles east-north-east of Kaladghi, the continuity of the belt is broken for a short distance; but another series of quartzites, shales, and limestones is met with at Múdebehál, and stretches away to the north-east into the Nizam's territory to the neighbourhood of Gúlbargá.

In the central part of the area around Kaladghi the quartzites are overlaid by a great thickness of limestones and shales; above these, again, comes a considerable quartzite series, which in its turn is overlaid by another set of limestones and shales. These different limestones, &c., occupy a considerable area in the valley of the Gatparbá, both east and west of Kaladghi. The limestones are generally subcrystalline and of various degrees of purity; they are often highly silicious, and many beds are very argillaceous—indeed often pass into calcareous shale.

The lower quartzites are considerably tilted along the greater part of the southern boundary and form a fringing ridge, with an abrupt scarp, overlooking the gneiss area.

The basement beds of the lower quartzite series contain many very remarkable conglomerate beds; the included pebbles being of banded jasper, quartz and felspar, derived from the gneissic series.

Some few beds of jaspery hæmatite-schist occur in the lower quartzite series in Balgi ridge north of Kaladghi.

Where the beds are lying quite undisturbed and horizontal they have not assumed the character of quartzites, but are true sandstones, but, wherever disturbed, the metamorphosing effect of pressure has changed them into more or less perfect quartzites. Two of the most beautiful and interesting scenes in Western India—the falls of the Gatparbá at Gokák and the "Naul Tirth" (the peacock's bath) in the gorge of the Malparbá river near Manóli—are due to the peculiar position of the lower part of the quartzites.

The series of quartzites which lies near Múdebehál eastward of the break above referred to differs from the Kaladghi series in several important points; the former consists of a thin basement-bed of pebbly sandstone overlaid by shaly sandstones, and these again capped by

limestones; the whole, as far as seen near Múdebehál and Tálikót, not exceeding 200 feet in thickness. The Kaladghi beds are of far greater thickness; the basement quartzites and conglomerates alone being many hundred feet thick; over which comes a great thickness of brecciated quartzite followed by the two great limestone and shale series above described and the upper quartzites which divide them.

The limestones also differ in character, those occurring at and around Tálikót being fine-grained lithographic limestones with few inclusions of chert, while those at Kaladghi are subcrystalline and full of chert both in laminæ and in irregular nodular masses.

From the differences above enumerated, it appears reasonable to conclude that the Múdebehál and Tálikót beds are not continuations of those around Kaladghi, but members of another, and from its lesser degree of metamorphism in all probability a younger system of rocks. This conclusion is strengthened by the fact that the quartzitic groups in the Madras Presidency are referable to two series—the lower or Kadapá series, probably representing the Gwalior series of Upper India, and the upper or Karnúl series, representing the Lower Vindhyans. For convenience of description, the name of the town Kaladghi has been given to the series of beds occupying so large an area of the Gatparbá valley, and that of the Bhímá series to the Múdebehál and Tálikót beds, as they are far more extensively developed in the valley of the Bhímá river. The beds at the base of Phondá ghât belong to the Kaladghi group.

Above the Vindhyans there is found in Central India and Bengal a most important series of formations, to a portion of which the only coal beds worked on the Indian Peninsula belong. The various groups, including the Talchír, Damúda, Panchet, Máhádévá, &c., are largely developed in the Central Provinces; but all disappear below the traps far to the east of the Bombay Presidency, and none of them have hitherto been detected along the southern edge of the trap area in Belgáon, Dhárwár, and Ratnagirí.

The absence throughout the Bombay Presidency of the coal-bearing Damúda groups, so widely spread in the Central Provinces and South-Western Bengal, is a serious drawback to the commercial prosperity of the country, and, coupled with the rapidly progressing destruction of the forests, threatens to leave a large portion of that Presidency as destitute of fuel as the Panjáb and parts of Madras. There appears to be but little hope of the discovery of useful coal in Western India in any large quantity.

III.—Oolitic Series.

The rocks of Kachh, first described by Captain Grant, have lately been examined by the Geological Survey. The formations below the trap occupy the northern half of the province and the hilly parts of the island in the Ran, and consist of two groups, the lower of which is distinguished by a prevalence of argillaceous beds, with which sandstones and limestones are intercalated, the upper group is marked by a predominance of coarse sandstone.

The shales of the lower group vary in colour and consistency, and they sometimes contain gypsum. Ferruginous bands are less common than they are in the upper beds. Locally, fossil shells, always of marine forms, are common in these rocks.

The sandstones of the upper group are white and felspathic, except towards the base, where they are brown in colour, and abound in ferruginous bands and nodules. Throughout the whole, but far more sparingly than in the lower group, shales are scattered, containing plant remains, often fragmentary and undefined, but, when recognizable, consisting chiefly of cycads and ferns. Some of the shales are carbonaceous, and in a few localities, as at Trombo north of Bhúj, thin seams of coal have been met with, but none hitherto discovered have been sufficiently thick to repay extraction.

These two groups, although contrasting in some respects, have much in common, most of the beds in each being similar to some in the other; nor can any absolute line of separation be drawn between them. As a rule, the marine fossils are peculiar to the lower and the plants to the upper group; but exceptions occur, and interstratifications of shale containing plants have been found between beds rich in marine fossils near Chari in the lower group; whilst, in the western part of Kachh, bands with marine fossils are intercalated in the upper. It is evident, therefore, that both form a continuous series without any important break, and that they are not of different geological epochs. The age is shown by the numerous marine fossils comprising many species of *Ammonites, Belemnites, Pleurotomaria, Astarte, Avicula, Gervillia, Lima, Nucula, Opis, Ostrea, Pholadomya, Plicatula, Trigonia, Rhynchonella, Terebratula, &c.*, to be of middle and upper jurassic age, some of the species being identical with those common in the same groups of Europe. The plant-fossils, on the other hand—including three species of *Palæozamia*, some conifers, resembling *Brachyphyllum, Taxodites* and *Walchia*, a *Tæniopteris*, and a *Sphenopteris*—are for the most part identical with those found in the beds intercalated with the lowest beds of trap in the Rájmahál hills of Bengal, and in some clays occurring beneath the cretaceous beds of the neighbourhood of Trichinopoly and at Sríparmatúr near Madras.

The whole thickness of the jurassic beds of Kachh, so far as they are seen, has been estimated by Mr. Wynne at 6,300 feet, of which 3,000 may be allowed for the upper group; but it should be borne in mind that this does not give the whole original vertical extent of the series, since their base is nowhere seen, and their upper surface had undergone denudation before being covered up by the trap.

It is not known that the Oolitic formations occur in the Bombay Presidency and its dependencies beyond the limits of Kachh. Some representatives of them may perhaps be found in northern Káttiáwár or in the neighbourhood of Dísa, but none appear as yet to have been made known. Dr. Impey near Jaisalmir (Jeysulmeer) found, in a well, some ammonites which Dr. Carter thought might be of jurassic age, but in fact the geology of Western Rájputáná and of the countries lying north of Kachh is very little known.

IV.—Deccan Series.

Lametá and Bágh beds.—The next great series in ascending order is far more important in Western India than any of those inferior to it in position, and it covers as large an area in the Bombay Presidency and its dependencies as all other formations together. The greater portion is of volcanic origin, consisting of stratified basaltic or earthy traps, but at the base of the igneous rocks, there is in the Narbadá valley, a very interesting group of sedimentary beds, which, from their geological relations, must be classed in the same series. These are the cretaceous strata of Bágh, Chota Udepúr, and Rájpipla.

In many places to the eastward, there is found at the base of the traps a bed of impure, earthy or gritty limestone, frequently containing pebbles, and passing occasionally into a sandstone or conglomerate. It has been traced throughout a considerable portion of the Narbadá valley and the country around Nagpúr. To this formation the name of Lametá was given by Mr. J. G. Medlicott from its occurrence at Lametá ghât on the Narbadá near Jabalpúr, and it was at one time supposed to represent, in part, the massive sandstones of the Máhádeo hills around Pachmari. This has now been disproved, but it appears highly probable that the Lametá bed is the equivalent of the limestones and sandstones of Bágh.

Wherever this infra-trappean formation occurs, its close connection with the overlying traps is manifest. The Lametá group is apparently of fresh water origin, having in all likelihood been deposited in lakes formed by the damming up of vallies by the first flows of lava, and it is therefore similar in its mode of deposition to the inter-trappean beds to be presently noticed. Fossils are but rarely found in it; the few that have been obtained are

fresh-water shells, reptilian bones (?) and wood. But although it is evidently of different origin from the Bágh group, its similarity in mineral character to the uppermost bed of the latter is most striking, and there is also great resemblance in the conformity of both Lametá and Bágh beds to the overlying trap, although this character is less striking in the Bágh beds in consequence of local unconformity.

Numerous small patches of infra-trappean rocks occur along the southern boundary of the Deccan trap in Belgáon and Kaladghi districts. They rest either on the Vindhyan or the gneissic rocks, and are invariably of small thickness, rarely exceeding 6 or 8 feet, and generally of even much less thickness. The beds consist generally of soft sandstones or marly sand with numerous quartzite and a few gneissic pebbles. The top of the beds just below the trap is most frequently stained of a rich red from the presence of red bole. In the only case, near Kaladghi, in which fossils were found in these infra-trappean beds, they were of fresh water types—*Physa, Lymnea*, and *Unio*. It is still uncertain whether these are true representatives of the Lametá group, or only local overlaps of the inter-trappeans.

The Bágh beds consist of limestone or calcareous shales and sandstone, the former being almost always above the latter. The 'coralline limestone,' which first attracted attention to them from the blocks in the ruined buildings of Mándú near Mohu (Mhow), is a red or yellow rock mainly composed of fragments of marine shells and *bryozoa*. The source of the blocks at Mándú was long unknown, but was in 1856 traced by Colonel (then Captain) Keatinge to Cherákhán, about twenty-five miles east of Bágh. This peculiar rock forms the highest bed of the group over a small area east of Bágh, but it is not seen near that town, and is only very imperfectly represented to the westward.

At Bágh itself, 20 or 30 feet of nodular limestone rests on 80 or 100 feet of sandstone, which is in places conglomeratic and sometimes argillaceous or shaly. To the west in Alirájpúr and Chota Udepúr, the mass of the cretaceous rocks consists of coarse sandstones and conglomerates, capped by gritty limestone or calcareous shales. In the Deva valley near Dúmkhal in the northern part of the Rájpipla hills, a section of 500 feet of these calcareous shales is seen resting upon an even greater thickness of sandstones, but to the north the group becomes of much smaller dimensions; like the Lametás, the uppermost beds frequently abound in chert.

The traps in general rest conformably upon the Bágh beds, but there is much local unconformity, showing that the latter had in places undergone considerable denudation before they were covered by the volcanic rocks. From the nature of this denudation there can be but little doubt that it was subaërial, and that the marine beds of Bágh had been raised above the sea and subjected to the action of rain and streams before their surface was encased in the overflowing trap.

The fossils found near Bágh are unmistakeably cretaceous; and Dr. Martin Duncan has shown that the Echinoderms found at Cherákhán are mostly identical with species found in the Upper Greensand (Cenomanien) of Europe. A few specimens are met with farther west, but less abundantly. The most common to the west are species of *Ostrea*, but teeth of Sharks, *Pecten 4-costatus*, and *Hemiaster*, also occur occasionally.

In the lower Narbadá valley the cretaceous beds fringe the trap, and are occasionally exposed within the area of the volcanic rocks. The principal inliers to the westwards in the Rewa Kanta are near the town of Kawát, and a large one exists in the Deva valley in Rájpipla south of the Narbadá; whilst on the edge of the traps, a tract covered by these beds, fourteen miles long from north to south by ten miles broad, is met with a few miles south-east of Baroda near the villages of Wasná, Talakwárá, and Gandeshwar.

Stratified traps.—These rocks have engaged the attention of nearly all the geologists who have written upon Western India. Their thickness, peculiar appearance, and extent render them the most conspicuous geological feature of the country.

Lithologically the trap rocks consist principally of various kinds of dolerite, rich in augite, the prevailing forms being compact basalt, anamesite, and more or less earthy amygdaloid. Two of the most characteristic rocks are a porphyritic basalt containing tabular crystals of glassy felspar, and an amygdaloidal earthy trap abounding in small nodules of agate and zeolite surrounded by green-earth; the latter of these is exceedingly abundant. Some of the amygdaloids contain great quantities of zeolites and allied minerals; of these the most abundant are *Apophyllite, Stilbite, Heulandite, Scolecite,* and *Laumonite.* Besides these *Chabasite, Hypostilbite,* and *Thomsonite* occur, but they are rare, and I have once seen *Prehnite.* The *Apophyllite* is finer than at any other known locality, and of various colours, white, green, and pink. A great variety of agates and of other forms of silica, such as bloodstone, are also met with filling cavities or forming small veins in the rock.

The traps of the trachytic group in which felspar predominates, and which may be recognised by their pale color, are much less common, and are in fact only met with in a few localities, as at Dharavi in Bombay Island, Powagarh hill, east of Baroda, &c. They are usually ashy or earthy, but sometimes crystalline.

The whole series of Deccan traps is regularly stratified in beds, or, to speak more correctly, flows, varying from 5 or 6 feet to upwards of 200 in thickness. The average in two roughly measured sections on the railway-inclines of the Tol (Thull) and Bhór ghâts is apparently 87 and 64 feet respectively, but really less, because the distinction between any two beds can, in general, only be made out by mineral characters, and if, as frequently happens, two successive strata present no lithological differences, they are liable to be classed together as one. Many apparently massive strata of amygdaloid really consist of a number of separate flows from 6 to 10 feet thick, and it is doubtful if the average thickness of the strata exceed 20 to 30 feet.

A remarkable horizontality prevails throughout the greater portion of the trap area, the most important exceptions being in the Rajpipla hills, and the ranges immediately north of the Narbadá, in parts of the Satpúra hills north of Khandesh, and along the coast from some distance south of Bombay to Damán. In these exceptional areas the dips are clearly due to disturbance subsequent in date to the consolidation of the rocks, for sedimentary beds, which must originally have been horizontal, have shared in the movement. It is thus clear that throughout the area the traps must have originally been very nearly level.

Yet there can be no question but that these rocks are of volcanic origin. In many places beds of breccia are interstratified, which must originally have consisted of volcanic ash. Some are met with on the northern part of the Bombay Island, at Sion hill, Palshachi hill, Flagstaff, and Rai hills, and more in Salsette, the caves of Kanhari being excavated in one of them. Several beds are cut through on the Kamatké ghât on the road from Púnah to Mahableshwar, and a very conspicuous instance may be seen at the lower gateway of the hill fort of Singurh near Púnah. Indeed with a little search similar beds may be found almost anywhere in the trap country. When weathered, the resemblance of these breccias, with their enclosed scoriaceous blocks, to the ash beds of old volcanic cones is so exact that no doubt can remain as to their being of identical origin. The red bole which so frequently occurs interstratified with the traps may also be an ash, as it is intermixed with scoriæ in places, but it sometimes bears the appearance of having been rearranged by water. It should not be forgotten that the blocks which were originally vesicular or scoriaceous are now amygdaloidal, the hollows in them having been filled by infiltration.

But whilst the volcanic origin of the Deccan traps is unquestionable, their horizontality and regularity of stratification render them very unlike the accumulations of volcanic rocks now forming in countries in which igneous vents exist, and it is clear that the circumstances under which the former were accumulated were widely different from anything now known to

occur on the earth's surface. Another remarkable distinction is the apparent absence, throughout a great part of the area, of any foci from which currents of lava could have been poured out. Of course cones of loose scoriæ would long since have been removed by denudation, and nuclei of solid basalt would not easily be recognised amongst flows of similar constitution. Still it is remarkable that so few instances should have been described. Unmistakeable nuclei exist in the lower Narbadá valley, some of them, as Metápenai hill south-west of Chota Udepúr, consisting of trachyte; and throughout a large tract in the Ràjpipla hills the rocks are cut up by immense dykes; but still better examples of volcanic foci may be seen in Kachh amongst the jurassic rocks, one of them being the so-called volcano of Dinodar,* west of Bhúj. Mr. Clark also (Quart. Journ. Geol. Soc., 1869, p. 163,) states that a line of vents exists in the Konkan east of Bombay, and that large numbers of dykes occur; but whilst it is highly probable that there are volcanic foci in this direction, it is doubtful if any large portion of the Deccan traps have flowed from them, for the frequent occurrence (locally, it is true, not universally) of trap dykes, and still more of ash-breccia appears to show that centres of eruption must have been scattered widely over the country, and it is probable that closer search will show their existence.

It is evident that the lavas were poured out in a very liquid state, and that they spread themselves in wide sheets of small depth over large areas of country. It is quite possible that the more earthy beds which form a very large proportion of the whole may have issued in the form of volcanic mud, not necessarily at high temperature. But the crystalline basalts were in all probability poured out as lavas liquified by heat.

Geologists generally have hitherto explained these peculiar phenomena by supposing that trap rocks similar to those of the Deccan have been poured out at the bottom of the sea, and in taking a different view, which I do with some diffidence, I know that I am in opposition to all the best authorities and to some at least of my own colleagues. It is considered that lavas would preserve their liquidity longer at the bottom of the sea under the pressure of the water; that they would consequently be spread over a large area; that there would, for the same reason, be vesicular structure, but not scoriaceous, and that cones of scoriæ would not be formed, because the ashes and fragments blown out from the crater would be spread over the bottom of the sea.

To this view there is one serious objection, which is, that some of the Deccan traps were subaërial or poured out in water so shallow that the pressure could not have affected them, and that these are undistinguishable from the mass of the beds; whilst, on the other hand, there is no evidence except the single occurrence of marine shells interstratified with the basalts near Rájámahindri to show that any portion of them were accumulated beneath the sea. In the case of Rájámahindri there can be no doubt but that some of the traps are submarine, and there can be equally little doubt but that they were poured out in a shallow sea or estuary close to land, for the marine shells found are of littoral or estuary species, not of deep water forms, and freshwater shells are mixed with them. It is equally clear that the bulk of the intertrappean sedimentary beds to be presently mentioned, wherever they are found from Mundla to Bombay, and from Dewad (Dhawud) in the Rewa Kanta to the Sichel hills of Hydrábád, are of freshwater origin, formed in small shallow lakes, and that consequently the greater portion of the surrounding country, over which the lava flows were poured out, was dry land.

Another proof that the lowest traps were subaërial is to be found in the form of the surface on which they rest. This is excessively uneven, valleys upwards of a thousand feet deep being found in it in places. This uneven surface can only have resulted from subaërial denudation; marine denudation, as has been amply shown, reduces the area affected by it to

* The reported eruption of this "volcano" in 1819 must be a mistake. There is no trace of any recent igneous action on the hill, which is not a volcanic cone, but a nucleus of basaltic rock exposed by denudation.

a plane. Had this surface, thus formed by the action of rain and rivers, been depressed beneath the sea before being covered up by trap, some traces of marine deposits must in places have remained at the base of the volcanic rocks conformably underlying them. But nothing of the kind occurs. The Lametá beds are of freshwater origin, and the Bâgh beds, which are marine, afford evidence of having been raised above the sea and acted upon by streams and rain before the lavas overflowed them. Now, the bottom flows are frequently some of the most compact and crystalline met with; they are as widely spread and as horizontal as any of the others. The same is the case in Bombay Island with the topmost flows; the basalt of Malabar hill, which rests on the freshwater shales seen at its base, is perhaps the most compact and most clearly stratified flow in the island, and that it must originally have been horizontal from Valúkeshwár to Warli, upwards of four miles, is evident, for it rests conformably everywhere throughout that distance on the sedimentary beds. If then the rocks at the base of the series throughout a large area, and those at the top at Bombay, are of subaërial origin, and these beds are as compact, as crystalline, and as distinctly stratified as the intermediate flows,–if, in short, there is no lithological distinction between the flows which are proved to have been poured out on the land and the great mass of the beds,–it is surely illogical to assert that the traps in general are submarine without adducing any other argument than their lithological characters.

The whole thickness of the traps cannot be less than 5,000 feet, probably it is more. The time occupied in their accumulation must have been great, for the sedimentary beds intercalated prove large periods of repose, during which lakes were formed and became stocked with living animals; and it is impossible to say how much of the interval between the Middle Cretaceous and the Eocene epochs was occupied in their formation. As before stated, they rest upon the Bágh beds, which are of Upper Greensand age; while upon them, after a break marked by great denudation, rest the Nummulitics, which are Eocene.

So far as physical evidence is concerned, the break at the base of the traps in the Narbadá valley appears less than that which separates them from the overlying Nummulitics near Súrat. In Kachh, a group of ferruginous clays intervenes between the traps and the Nummulitics. For these reasons I am myself disposed to look upon the lower traps at least, and consequently on the freshwater beds of the Narbadá valley and Nágpúr, as probably Cretaceous. But most geologists are inclined to class the whole of the volcanic series as Eocene.

The traps cover the whole of the Bombay Presidency from the Narbadá river as far south as the parallel of Goá in the neighbourhood of Belgáon and Kaladghi. North of the Narbadá in the Rewa Kanta they occupy but a small area ending abruptly south of Chota Udepúr. Powágarh hill is an isolated mass; and there is a larger tract composed of them around Dewad. A belt of them extends partly across Káttiáwár, and another, five to ten miles broad, throughout the greater part of Kachh, the dip being to the south. Traces may perhaps be detected farther to the westward, as at Ránikot in Sind, but no absolute proof of their existence has been found.

Intertrappean beds.—To these reference has just been made. The most important are limestone, calcareous shale, chert, and more rarely sandstone, containing in abundance remains of plants and freshwater shells, the most common being *Physa, Lymnea, Paludina, Melania, Unio,* &c. The beds containing these fossils have not hitherto been found more than 300 or 400 feet above the base of the traps. Each bed can rarely be traced for a longer distance than three or four miles, and seldom exceeds 2 to 3 feet in thickness; but successive beds are met with, trap flows intervening, sometimes as many as three sedimentary intercalations being met with one above the other, and often differing from each other in mineral composition and in the fossils contained. That these beds have been deposited upon the underlying trap, and that the overlying flow has been poured over them, is clear, because the upper surfaces of the freshwater bands are always hardened and altered (though sometimes to a very slight degree) and their base is unchanged.

In the Bombay Presidency, the only known localities for these "Physa beds," as they have been called from the prevalence of that shell (they are the Tákli beds of Hislop), are near Dewad (Dohud) in the Rewá Kántá (Rogers, Quart. Jour. Geol. Soc., 1870, p. 118,) and in Western Kachh, where they have recently been found by Mr. Fedden, of the Geological Survey, and near Kaladghi, where Mr. Foote, of the Geological Survey, discovered a thin bed of sandy marl lying beneath the lowest trap flow and the gneiss.

Near Gokak, in Belgáon district, Mr. Foote found fossil *Unios* in a thin bed of sandstone resting on a flow of amygdaloidal trap, which forms locally the base of the trap series, and was poured out over the rugged surface of the gneiss. The sandstones overlap the amygdaloid bed in places, and rest directly on the gneiss.

The intertrappean beds of Bombay belong to a very different horizon, being intercalated with the very highest trap flows hitherto explored, and their fossils are distinct, with one exception (a species of *Cypris*), from those found in the lower group of sedimentary deposits. The Bombay intertrappeans are composed of shale, and are of freshwater origin, as is proved by their containing frogs, freshwater tortoises,* *Cyprides*, remains of insects, and land plants. As in the group near the base of the traps, there are in Bombay several successive deposits with lava-flows intervening. They have been traced into the island of Salsette, but not farther, probably for want of searching for them.

The origin of these freshwater deposits is easily conceived. Flows of lava spreading over an uneven land-surface, cut into hills and valleys by subaërial denudation, must have dammed up the valleys of streams and converted them into lakes. Other flows might fill up the first lakes, but by isolating fresh hollows would produce fresh ones, for the flows, however liquid, could not have presented an absolutely plane surface, and the outbursts from different foci must have crossed and dammed up the hollows between flows from the same crater. The absence of sedimentary beds in the centre of the series may be due to the greater rapidity of deposition or to the peculiar climate produced by the wide spread of volcanic outbursts and to want of rain.

It is rather singular that fossils should be so much more common in the beds intercalated with the traps than in the Lametás at their base, although such shells as have been found in the latter are apparently similar to those met with in the former.

The traps and their associated beds have been treated at somewhat greater length than the other rocks on account of their great importance in Bombay, and the remarkable geological interest attaching to them.

V.—Older Tertiary Series.

The last of the great rock systems in ascending order is far less thoroughly known than most of those lower in the series. Although the abundance of organic remains found in it, foraminifera, corals, echinoderms, and mollusca in the lower beds, and bones of vertebrata in the higher, have attracted attention, not only in India, but amongst the palæontologists of Europe, very much remains to be done before the sequence of beds and their faunæ can be said to be properly known. It has been pointed out, and with every appearance of probability, that the fossil forms from Sind described in the "Description des animaux fossiles du groupe nummulitique de l' Inde" by M. M. D'Archiac and Haime must have been derived from formations varying to a considerable degree in age, and it is highly probable that a thorough examination of the Sind rocks will show the necessity of sub-dividing them to a far greater extent than has hitherto been attempted.

* The frog named *Rana pusilla* by Owen has been shown by Dr. Stoliczka to be an *Oxyglossus*. The tortoise named *Testudo Leithi* by Dr. Carter is not a *Testudo* (as indeed has been shown by Dr. Carter), but belongs to *Emys* or some allied genus.

In the present state of our knowledge it appears to be most in accordance with what information we possess to include in the older tertiary series all the rocks in Western India above the trap up to and including the beds of Perim and the Siváliks. It is true that Dr. Falconer has pointed out the connexion between the fauna of the Siváliks and that now living, and the absence of any great break in the chain of life; and it is possible that when the Indian tertiary formations are better known, a different sub-division to that now proposed may be desirable ; but at present all that can be said is that the *series* as here proposed does appear to exist in Western India, and that, so far as is known, there is a break at its close.

So greatly do the beds of the Tertiaries vary, and so little has been done towards their correlation, that it is impracticable to describe them so generally as has been done in the case of the older formations; and, in order to give a fair idea of them, it is necessary to explain briefly the succession of beds in the different districts in which they are found, commencing in eastern Gújrát and thence tracing them across to Sind. The general succession appears to be sandy and argillaceous beds deposited in part in rivers or estuaries, and containing remains of land plants and animals at the top and base, and marine beds, some of them limestones formed in deep water, in the middle of the series. This is especially the case to the westward.

Súrat and Bharoch.—At the base of the tertiary formations near Súrat are thick beds of ferruginous clay assuming, where exposed, the characteristic brown crust and pseudo-scoriaceous appearance of laterite, from which they differ in no respect. These at first sight appear to be of volcanic origin, an idea which is strengthened by the neighbourhood of the traps on which they rest, but close examination has shown that they are really sedimentary deposits, although composed in all probability of materials derived from the disintegration and denudation of the trap. With them are interstratified beds of gravel or conglomerate containing agate pebbles (the agates derived from the trap), and limestone, sometimes nearly pure, but more frequently sandy, argillaceous or ferruginous, and abounding in nummulites and other fossils, many of them identical with those found in Sind and in the Eocene rocks of Europe.

Above the limestones and laterite beds there is found a great thickness of gravels, sometimes cemented into a conglomerate, sandy clay and ferruginous sandstone, often nodular. These contain fossils also, though not in such abundance as the lower limestones, and the species are different and perhaps belong to a higher horizon. Hitherto, however, they have not been properly examined and compared. There is some evidence in favour of unconformity between the two groups ; the lower, which is well seen about Tarkésar and Gula east of Súrat, being apparently overlapped by the higher beds to the northward.

These higher beds are but poorly exposed in the Tapti river near Gutta and Karjan, and in the Kím between Kimamli and Elao, but they are well seen in the stream which runs past Ratanpúr east of Bharoch. Here they consist chiefly of sandstone, gravel, and conglomerate, with occasional beds of red or white clay and shales. The pebbles in the gravels and conglomerates are mostly of agate and other quartzose minerals derived from the traps; and from some of these beds the carnelians and agates are obtained, which have from time immemorial supplied the lapidaries of Khambayát.

The Eocene rocks in Súrat and Bharoch form merely a fringe along the edge of the traps; and they are covered and concealed to the westward by alluvium. A few traces of them have been found south of the Tapti, but none have hitherto been detected north of the Narbadá.

Perim Island.—The rocks of Perim Island in the Gulf of Khambayát are isolated ; and it is difficult to say whether they belong to the group just described, or whether they are a portion of a newer formation altogether. In some respects they resemble the beds of the

Kím and Tapti. The island is small and flat, and the rocks being horizontal, very little is seen of them; the most characteristic bed is a coarse conglomerate containing blocks of fine sandstone and agate pebbles. With these are intermixed large masses of fossil wood and bones of various mammals, some of which have been identified with those of Siválik species. Amongst the remains found here are *Mastodon latidens*, *Sus*, *Dinotherium*, *Bramatherium*, and *Camelopardalis*. These mammals show the age of the beds to be Miocene.

Káttiáwár.—Ossiferous conglomerates like those of Perim are found also on the Káttiáwár coast near Gogo, though bones appear to be less abundant than at Perim. The conglomerates rest upon thick blue clay. These beds extend as a very narrow belt along the Káttiáwár coast to the neighbourhood of Gopnáth. Here they are replaced to a great extent by mottled clays and coarse rubbly limestone, fossiliferous in places, upon which rests a fine-grained calcareous rock known as milliolite, which apparently marks a higher horizon and will be described amongst the later Tertiary beds.

The rubbly limestone and clay is not fossiliferous near Gopnáth, but becomes so farther to the west. From Safirábád to Patan it is concealed by milliolite; but still more to the westward it is exposed in places and abounds in Eocene fossils.

Kachh.—The Nummulitic rocks and their associates are only found in the western part of Kachh, being overlapped by higher beds east of the neighbourhood of Mandavi. At their base, however, are some variegated clays and beds of laterite which have a much wider distribution. These beds are conspicuous from their brilliant contrasts of colours, red, purple, and white, many of them being highly ferruginous. They sometimes contain pebbles of agate, and upon them rest coarse sandstones and red, brown, and white shales with impressions of land plants. The thickness of this group varies from 20 feet to about 200, increasing towards the north and east. They appear in general to rest conformably on the traps, and it is possible that the lowest beds which have in places a very ashy appearance may have been formed before the termination of the volcanic action to which the subjacent traps were due. This at least is Mr. Wynne's opinion. Nevertheless these clays and laterites locally, as at Mharr and near Lakhpat, overlap the whole of the traps and rest upon the underlying jurassic beds, a circumstance which appears rather opposed to their being really conformable to the traps.

Upon these variegated clays, in the western part of Kachh, rest conformably fine laminated shales, containing plant remains in places, and pyritous and bituminous towards the base. The fossils both in these beds and in the variegated clays are chiefly leaves, endogenous and exogenous. As will be seen presently, these pyritous shales and richly coloured clays with plant fossils are well developed in Sind.

The general section of the Nummulitic beds in Kachh above the plant beds is the following, as abridged from Messrs. Wynne and Fedden's report:—

DESCENDING SECTION.

	Ft.
1.—Clays and shales occasionally sandy, with hard bands of shaly limestone or of marl, and a few sandy and conglomeritic beds. The upper portion highly fossiliferous	800 to 1,200
2.—Sandy shales, mottled white or ferruginous, irregularly bedded, with impressions of leaves	100
Dun-coloured and blue silty clays and shales, with minute crabs	30
3.—Nummulitic marls and limestones—Fossils numerous ...	700
4.—Gypseous shales and marls, with foraminifera, oysters, &c.	100

These are not regularly interstratified; some of the divisions are of local occurrence, No. 2 being only found on the flank of the Gaira hills, and a few other places, while No. 4 is also deficient in places. The thickness given is approximate only.

The nummulitic group, No. 3, consists of pale, yellow, and white argillaceous limestones with some sandy beds and shaly marls. The massive and compact nummulitic limestones of Sind do not appear to extend to the westward.

The argillaceous group, No. 1, is the most important of all in Kachh, and it contains the greatest number and variety of fossils. It perhaps represents the clays and limestone of Káttiáwár, and it may be the equivalent of the gravels and conglomerates of Ratanpúr near Bharoch. But it is far from clear that this is the case.

West of Kachh the delta of the Indus makes a great break in the belt of tertiary deposits bordering the coast, and when the rocks again emerge from beneath the alluvium in Sind, the border groups of India have been left behind, and the great nummulitic limestone tract entered, which extends from the Himálayas to the Mediterranean. In Sind itself no rocks older than the Tertiaries are known to occur, but to the west in Kelat, mesozoic and palæozoic strata have been found by Dr. Cook, which are probably a continuation of the beds known to exist in the Salt Range.

The following general section of the beds in Sind is given by Captain Vicary:—

1.—Conglomerate.
2.—Clays and sandstone.
3.—Upper bone bed.
4.—Sandstone—fossils rare.
5.—Lower bone bed.
6.—Coarse, arenaceo-calcareous rock, with *Cytherea exoleta?* and *C. exarata*, *Spatangi*, no nummulites.
7.—Pale arenaceous limestone with *Hipponices*, *Nummulites* and *Charoideæ*.
8.—Nummulitic limestone of the Hálá range.
9.—Black slates—thickness unknown.

Probably a thorough examination of the country would produce some important modifications in this list. What the black slates No. 9 may be it is difficult to say from Vicary's description, as he does not refer to them further, and it is doubtful if they occur within the limit of Sind.

Beneath the limestone of the Hálá range and of Kotru (Kotree), which appear to be identical, there is a great thickness of variegated sands and clays containing leaves of plants, and in one or two places small lenticular beds of lignite. These beds undoubtedly represent the somewhat similar formation below the nummulitic marls and limestone of Kachh. A rough classification of the Sind rocks, so far as they are known, may be attempted thus:—

DESCENDING SECTION.

1.—Conglomerates, clays and sandstone with fossil bones; (Nos. 1 to 5 of Vicary). These are the equivalents of the Siválik and Perim beds, and are known to be of Miocene age.

2.—Limestone, more or less pure, passing into sandstone and of variable character (6, 7, and 8 of Vicary.) Towards the base are massive beds of white limestone of great thickness abounding in *Alveolina*, a small spheroidal foraminifer. It is highly probable that further examination will show the necessity of sub-dividing this group.

3.—Variegated sands and gypseous clays, with remains of plants.

At Karáchi itself the only rocks seen belong to newer beds than any of those now described, but to the north-west near Magar Pir an impure limestone is met with, containing numerous mollusca and operculina, but nummulites are scarce if they occur at all. From Karáchi to Kotru (Kotree) various forms of nummulitic limestone cover the country. Near Kotru itself white compact limestone with *Alveolina* is found, whilst to the westward, a considerable area is covered by the variegated sands and clays. Amongst these, north-west of Kotru, occurs the lignite of Lynyan, an attempt at mining which was once made. The quantity of the mineral was, however, found to be small owing to the rapid thinning out of the bed, and the quality was inferior.

At Ránikót, a gorge in the Eri hills, twenty miles west of the Indus at Magendan, and forty-five miles north-west of Kotru, about 1,000 feet of massive alveolina limestone rests on 1,300 feet of variegated sands and clays, at the base of which trap is seen. Whether this trap be intrusive or not has not been ascertained; it appears stratified and is slightly amygdaloidal. Of course, the occurrence of igneous rocks below the lowest of the rocks known to be associated with the nummulitic limestones recalls the similar association of variegated clays resting upon traps, these unmistakeably belonging to the Deccan series, in Kachh; but it has by no means been definitely ascertained whether the trap in Sind is a representative of the Deccan series. The Eri hills are an outer ridge of the Hálá range and terminate to the north at Sewan. The Hálá range stretching along the frontier is said to be entirely composed of limestone. Further to the north, and to the north-west of Sewan, conglomerates and sandstones of Siválik age with mammalian bones are found along the flanks of the main limestone ranges. The greater part of Upper Sind is an alluvial plain.

Laterite of the Deccan.—Although the age of the laterite found locally on the crest of the Sahyadri and in the southern Marátha country is extremely obscure, there appears some probability from its mode of occurrence that it should be referred to the older and not to the newer tertiaries. Its occurrence in isolated caps on various hills appears to indicate that all now seen is merely the remnant of a formation once far more widely spread, and its striking resemblance to the beds already mentioned as occurring in the Nummulitics of Súrat renders it possible that the two may be of the same age.

Laterite is essentially a clay strongly but unequally impregnated with iron peroxide, to which it owes its deep red colour, which, however, is far from uniform, the surface of a freshly broken fragment being veined and mottled with different tints, from white to deep red. Sometimes the appearance is almost that of a breccia from the angular white fragments enclosed. In some places, as at Bidar, the rock is intersected by small irregular tubes, lined with hydrated peroxide of iron, but these are not always present. The surface has a very characteristic appearance, being very irregular, owing to the washing away of so much of the clay as has not been impregnated with iron, and being covered with a glazed coating of hydrated iron peroxide or brown hæmatite. In the newer forms of laterite (for the rock is of various ages) grains of quartz and small pisolitic ferruginous concretions are usually found in considerable numbers, but in the rock which occurs at high elevations in the Deccan these are often deficient.

Of the origin of this singular rock but little can be said. In consequence partly of its peculiar pseudo-scoriaceous appearance, and partly of its occasional passage into decomposed trap at its base, it has by many geologists been classed with the volcanic rocks. But it has never been found intercalated with traps, and it is met with interstratified in the sedimentary Eocene strata; moreover, its conformity to the trappean flows is only apparent, since the same laterite is found in some places resting on traps much lower in position than in others, *e. g.*, at Mahableshwar and Panchgain, it rests upon flows very high in the series, while at Mátherán and Khandála it is found on much lower beds. It is therefore fairly evident that the Deccan laterite is a rock of aqueous origin and newer than the volcanic

series, from the detritus of which it is probably formed; but by what process it has accumulated—whether it be of marine, fluviatile, or subaërial origin—is extremely difficult to say, the more so because, as is frequently the case in highly ferruginous rocks, no fossils are found in it.

Laterite has a remarkable power of resisting disintegration, and wherever a cap of it is found on a hill, the lower ground around, if sufficiently flat, is covered with a thick coating of reconsolidated débris. The iron washed out of the laterite tends always to change any decomposed rock, such as trap or gneiss, beneath it into a substance so precisely resembling the laterite itself that there is generally an apparent passage from one rock to the other.

VI.—Upper Tertiary and recent beds.

Of these rocks, like the last, the classification as yet is most imperfect; indeed the line drawn in some places between them and the beds described in the last section is quite arbitrary. It is possible and even probable that some of the formations here included in each may ultimately have to be placed in the other series.

Upper Tertiary beds of Káttiáwár.—Along the coast of the Káttiáwár peninsula a fine porous calcareous rock occurs, which is widely known as milliolite, or Porbandar stone, and exported under this latter name to Bombay for building purposes. It was found by Dr. Carter, who examined it, to consist of minute foraminifera with a few grains of quartz and hornblende. This rock varies much in mineral character in different places; near Gopnáth point, which is its easternmost extension, it is much less pure than to the westward, being much mixed with clay. It is everywhere strongly marked by irregular oblique lamination or false bedding, showing deposition by currents.

Except the foraminifera the only fossils hitherto found have been *Pupa insularis* and some other recent species of land shells which Mr. Theobald obtained. The occurrence of these shells is the principal reason for placing the bed amongst the newer Tertiaries; although, as some existing forms are said to occur also in the Siváliks, the evidence must not be considered as conclusive. Of the thickness attained by the milliolite nothing trustworthy is recorded. It is found throughout nearly the whole south coast of Káttiáwár.

Upper Tertiaries of Kachh.—In Kachh, there is a higher sub-division of the Tertiary beds, chiefly developed to the westward, that is, in that part of the province in which the older Tertiaries are wanting, and apparently unconformable to the latter. The following is the section given by Messrs. Wynne and Fedden:—

Descending.

Variable deposits, including concrete beds of great thickness.

Soft sandstones, shelly, calcareous and quartzose grits, gravels and conglomerates with trap pebbles and agates.

Brown sands and sandstones with fossil wood.

The thickness varies from 200 to 500 feet. The only distinguishable fossils are some large oysters, which are met with in the thick obliquely laminated concretes of the upper group. These oysters closely resemble the species now living on the coast of Kachh. It is not at all clear whether this concrete represents the milliolite of Káttiáwár, or the sub-recent calcareous shelly rock to be hereafter described.

Ossiferous gravels of river-valleys.—In parts of the Narbadá and Godávari valleys gravels have been met with containing bones of extinct mammalia much more nearly allied to existing forms than are the species found in the Siváliks. In the Narbadá, the deposits of which have been far more fully explored than any others, the bones belong to

species of *Elephas, Hippopotamus, Sus, Equus, Bos, Cervus, &c.*, associated with fluviatile shells of existing species. The age of these beds is by Dr. Falconer considered to be Pliocene.

A skull belonging to *Elephas Namadicus*, one of the Narbadá species, molars of *Bos*, and some other bones have been found in the banks of the Godávari near Paitan (Pyton) on the road from Ahmadnagar to Jálnah; and in the same gravel a well-marked agate flake, which has every appearance of human manufacture, was obtained by Mr. Wynne in 1865.

There is every probability that these bone-gravels are dispersed over a large portion of the country, and enormous quantities of bones have been occasionally exposed in the Godávari valley. An elephant's tusk was exhumed some years since by Dr. Cook near Satárá, and during the present year (1871) information has been received of the discovery (in Rígar) of a rhinoceros skull by Mr. Foote in the valley of the Gatparbá near Gokák. It is singular that no fossils have hitherto been obtained from the Tapti valley in Khandesh.

Surface gravels of Sind.—The plains of lower Sind to the west of the Indus and in the neighbourhood of the Hálá range are covered over to a considerable depth with gravel, composed of limestone and sandstone pebbles derived from the hills. In places torrents have cut through thick accumulations of these beds. It is evident that these gravels consist of detritus carried down by the wash of rain and streams; but from the denudation they have undergone in places portions of them must be of considerable antiquity. No organic remains appear to have been found in them; but they are worthy of closer examination than they have hitherto received.

Laterite of the Konkan.—The laterite of the western coast is of later date than that of the Deccan; and its derivative nature is proved by the occurrence of sand and small pebbles; yet, except in being more sandy, it closely resembles the older rock, from the detritus of which it may be partly derived. It occurs as a thick bed capping the traps and forming a plateau at a general elevation near Ratnagiri of between 200 and 300 feet above the sea. It had once covered the whole country; but numerous ravines have been cut out of it by streams. At Ratnagiri there is a bed of white clay containing remains of plants below the laterite.

The mode of formation of this rock in the Konkan is nearly as obscure as in the Deccan; but its position in this case renders it more probable that it may have been originally a submarine formation, deposited at a period when the Konkan was at a lower level and the sea washed against the cliffs of the western ghâts. It is not easy to say whether this really was the case, but there is no improbability in it. The deposit may have been greatly changed by subaërial action after its emergence.

Laterite is not found far north of Ratnagiri, and near that place only extends about fifteen to twenty miles inland. It extends farther towards the foot of the ghâts near Phonda ghât, but in Sawantwari is again limited to a band ten to fifteen miles broad. It covers a considerable area in the Goa territory.

Patches occur at a lower level scattered over the country; but these consist of a kind more mixed with gravel and sandstone. The peculiar character of this rock and the tendency of the detritus from it to reconsolidate must always be borne in mind when examining it.

Alluvium of Sind, Kachh and Gújrát.—In the north-western part of the Bombay Presidency there are extensive alluvial plains to which, in a sketch of the geology of Western India, a few words must be devoted. The sands and clays of which they consist are river-valley and delta deposits, washed down by the streams, and accumulated in the lower portions of their course and at their mouths. By far the most important of these compose the great plain extending to the east from the Indus.

A glance at the map will show that from Háidarábád in Sind to Ahmadábád in Gújrát is an almost unbroken flat. This flat is the south-western extremity of the great plain which stretches across Northern India and comprises the valleys of the Indus and Ganges. That this plain was at one time an open sea is suggested partly by the line of division which it forms between the two entirely distinct geological provinces of the Indian peninsula and the Himálayas, partly by the Tertiary marine beds which fringe so large a portion of its edges. The high grounds of Kachh and Káttiáwár are surrounded on all sides by portions of this flat or by the sea.

There appears much probability that the conversion of this vast area into land has been due in great measure to the silt, sand and gravel brought down by the various streams and rivers which emerge from the Himálayas and Bilúchistán on one side and from the Indian peninsula on the other. The process has doubtless been gradual and is still in progress. Locally, elevation may have aided, but, on the whole, there is probably at least as much reason to assume depression to have been the prevailing movement of the surface.

The Ran of Kachh appears to have been an inlet of the sea which has been gradually filled up by the silt deposited from the streams which enter it. This tract of country is still in a debateable condition, being covered with water in the south-west monsoon, when the floods brought down by the Banás and Loni, and by the small streams of Kachh, are forced back by the waters of the Gulf of Kachh and the old Korí mouth of the Indus, raised above their usual level by the force of the south-west wind, whilst during the remainder of the year the whole region is dry land, except in patches. There is a tradition that, at no distant period, the Ran was a navigable inland sea; and the appearance of its shores, with the occurrence of subrecent marine deposits, confirm this idea, although the period of its conversion into dry land remains doubtful, the evidence of the discovery of old boats being confined to localities which may have been covered with water after the greater part of the region was dry land.* Formerly it is probable that the eastern branch of the river Indus discharged itself into the Ran, and the quantity of silt deposited may have been much greater than is now the case.

On the eastern side of Káttiáwár the Gulf of Khambáyat is also said to be silting up. The evidence as to the rapidity of the process is not conclusive, but it may fairly be assumed that a gradual extension of the coast is taking place. On the east of the gulf, the Sábarmati, Málu, and Narbadá, the last being one of the great rivers of the Indian peninsula, all discharge themselves; and the quantity of silt and detritus brought down by them must be very great.

That the Gulf of Khambáyat once communicated with the Ran is probable, as a belt of low land, including the brackish marsh known as the Nal, still connects them. Mr. Rogers (Quart. Jour. Geo. Soc., 1870, p. 118) has pointed out that while the black soil of southern Gújrát is probably derived from the neighbouring trap rocks, the light-coloured alluvium to the northwards may have been brought down by the rivers flowing from countries still further to the north; and he has speculated on the possibility of the Indus having once discharged its waters in this direction.

Elevation may also have played its part in the conversion of these alluvial tracts into dry ground; and there is better reason for suspecting its action here than farther to the northward; for, along the south coast of Káttiáwár marks of a comparatively recent rise are numerous. In a MS. report by Mr. Theobald, written in 1858, mention is made of the occurrence of barnacles and serpulæ on the foundations of an old building beside a creek at

* Nothing appears to be said of any sea north of Kachh by the Buddhist-Chinese travellers of the seventh century.—*See* Cunningham's Ancient Geography of India, Vol. I, p. 302.

Pátán, which are now only reached by high floods; and dead oysters, evidently quite recent, were found in various creeks and especially in one at Porbandar, 20 feet above the level at which they now live. The evidence collected by Mr. Theobald appeared to show that a rise of 10 feet had taken place in the course of the year 1856. The changes of level in the Ran of Kachh during the earthquake of 1819 are well known, but in that instance, elevation of one tract was accompanied by depression in another. The vast expanse of water which Sir A. Burnes found around Sindri in 1828 has, however, now been mainly reconverted into dry land; and Mr. Wynne in 1868 reached the ruins of Sindri fort from Kachh on a camel. This change appears due to the deposition of silt, the cause to which may be attributed the conversion of the whole Ran into a land area.

Alluvium, besides occupying the delta of the Indus, the Ran of Kachh, the southern coast of the same province, and a large tract extending northward and eastward from the Gulf of Khambáyat, covers nearly the whole of Súrat district, and occupies a considerable proportion of the country to the southward, forming plains which, near the coast, intervene between the trap hills as far south as Bombay. It appears probable that some of the hills in the Northern Konkan have been promontories or even islands in the sea, and it is recorded that within historical times the hills of Bombay island were unconnected with each other. Their union has been due partly to artificial means, but chiefly to the accumulation of sand and silt. Unquestionably, unless man interfere, or some great change take place in the configuration of the country, the harbour of Bombay, the sole survivor of the inlets, which must once have been numerous, must be gradually silted up in the course of age. But as no stream of importance enters the harbour, the process is not likely to be so rapid as to cause serious concern as yet to those interested in the commerce of the port.

Littoral concrete.—An agglutinated calcareous mass of shells and gravel is found in many places along the coast. Some is seen in Bombay island, the esplanade consisting of it, and a part of the fort being built upon it; it also occurs at Mahim and in places on the shores of the harbour. To the northward it is met with here and there as far as Damán; it may show slight elevation of the coast line, but the amount of rise is very trifling.

Upon the milliolite of Káttiáwár the same formation is much more largely developed. It here assumes the appearance of a calcareous grit, containing marine shells and corals, and occasionally attaining a thickness of 60 feet. The species of animals found in it are, so far as is known, identical with those now inhabiting the coast. The evidence thus afforded of a recent elevation is an addition to that previously quoted.

Black soil.—Soils scarcely enter into the geology of a country, as they are simply the surface altered by exposure, organic agency and agriculture, but it is impossible entirely to overlook the widely spread "rigar" or "cotton soil." This is a black, grey or brown loam, varying much in character; tenacious and adhesive when wetted; light, crumbling and intersected by cracks when dry. It is found throughout the trap area, being in this instance a product of the decomposition of the volcanic rock, and every step in the passage from one to the other may often be witnessed in small roadside sections. It does not, however, follow that all soils derived from the trap are black, nor that no black soil is produced by the decomposition of other rocks. Red soil is often seen within the trap area; and true cotton soil, inferior in fertility, however, to that produced by the volcanic formations, is met with in Southern India, in the Káveri valley for instance, in a country which there is no reason to suppose ever contained trap. A very similar black alluvial deposit forms in the back-waters of the coast.

"Rigar," in short, appears to be a more or less argillaceous soil, impregnated with organic matter.

In the preceding sketch no attempt has been made to write a geological history of the country; for that purpose far more data must be accumulated than are at present available. Very much remains to be done before the geology of Western India can be said to be even tolerably well known. Of the rocks in many parts of this immense area, no descriptions exist except occasional notes collected by travellers; and even in the portions to which the Geological Survey has been extended, the examination has, in many cases, been but partial and preliminary. There is yet a wide field open to the geologist and naturalist, and there is no part of India which will in all probability more thoroughly repay careful search and enquiry than the Bombay Presidency. The chemical and lithological peculiarities of the trap formations and the minerals contained; the fauna and flora of the intertrappean beds; the multitude of organic forms in the Nummulitic rocks of Gújrát, Kachh, and Sind; the mammalian bones of the Miocene and Pliocene conglomerates and gravels;—all promise a mass of important discoveries to any one who will devote time and labour to their investigation.

W. T. BLANFORD.

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DEPT. AGRICULTURE, U. S., AMERICA.

July 3rd, 1872.

Note.—The following mistakes escaped notice in the first part of the present volume :—

Page 18,	*line*	8,	from bottom,	*for* Hæmatite	*read*	Tremolite.
,, 20,	,,	3,		,, say	,,	vary.
,, 20,	,,	12,		,, chrysolite	,,	chrysotile.
,, 20,	,,	39,		,, and crystalline	,,	to finely cryst.
,, 22,	,,	4,		,, starry	,,	strong.
,, 22,	,,	5,		,, falls	,,	fuses.
,, 22,	,,	11,		,, white	,,	rutile.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1872. [November.

NOTE ON EXPLORATION FOR COAL IN THE NORTHERN REGION OF THE SATPURA BASIN, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

In anticipation of a detailed report of work in the Satpura coal basin, this notice is given of any results of practical interest. The coal mines of the Sitariva, and the explorations in connection with them as working from the only outcrop of the measures on the north-side of the Satpura basin, have naturally been looked to for information to guide us in estimating the chances of success in other analogous positions. In previous reports I have mentioned the disappointing want of information derived from this source, and I regret that the same disappointment has again to be expressed regarding the point upon which information was most needed—the extension of the coal seams to the south, towards the dip of the basin. A boring was attempted this year at the edge of the Sitariva, south of the present colliery; but it came to a stand-still at 194 feet, in the Máhádévá clay and conglomerate, short of the calculated depth at which the measures might have been struck. Upon this most important point, therefore, we still know no more than might be learned from the exposed outcrops. It was always upon success in this direction that the best prospects of the mining concern were considered to lie; so, to a great extent, it may be said that those prospects are as good as ever they were. The somewhat intricate stratigraphical features noticed in my detailed report of last season's field work may add some little anxiety as to the depth to which the coal may have to be followed; but practically this should at present only add to the urgency for vigorously prosecuting the exploration to allow for the opening out of a new mine in deep ground before the exhaustion of the very limited supply at present available.

Notice has also to be taken of a failure of a more positive kind in connection with the exploration of the field within the outcrop of the measures between the present mines and the north boundary of the basin. In reporting upon the field in May 1870, before anything had been done to try the ground, I stated the geological possibilities of the case thus :—"It may be said that there are about two miles of known outcrop, the coal being obscurely visible at the surface at several spots along the curved line between the two collieries, *but its thickness or its quality in that position has not been tried.* Assuming it to maintain a mean thickness of workable coal between the aggregates at the two collieries, say 25 feet, (at the rate of 1,000 tons per foot of thickness per acre of seam), we should have 400,000 tons for every 66 feet down the seam along the whole length of two miles. As at many places the seam may be followed for many hundred feet, it is apparent that, without any very unwarrantable assumption, we may count upon a large supply of coal for many years to come." I observe in a recent report of the Narbadá Coal and Iron Company (published in the 'Mining Journal' for July 6th, 1872), use has been made of the last words of this quotation,

without any mention of the conditions so pointedly attached to them, and without any notice of the unfavorable realization of those conditions as proved in subsequent trials and as already published in my report of May 1871 (Rec. Geol. Sur., Vol. IV., page 67). Some further trials during the past season in the same ground to the north of the mines have not resulted in anything more hopeful. Shallow pits and galleries were driven upon the outcrop in several places, but the seam, besides being greatly crushed, exhibits much original impoverishment, shale having to a great extent taken the place of coal. It is certain, however, that this change is only a local accident, not a steady northerly extension of the coal, for in the vertical seams still further north, in the abandoned mines of the Sitariva Company, the coal, though ruined by the crushing it has undergone, does undoubtedly represent a rich deposit.

This fact of rapid local change suggests an explanation of a very puzzling structural feature in the Narbadá Company's mine. It has been often mentioned how the massive bed of coal stops out on the north-east against a steep face of sandstone. Although there were little or no signs of friction, and sometimes not even of crushing in the coal, this feature was accepted as a fault, having, according to the ordinary rule, an upthrow on the north-east. On this supposition a gallery was driven across the bedding, the dip being north-easterly, to find the coal beyond the fault; shafts were also sunk on the hill above the fault on the north-east, but without any success. On the chance of its being a reverse fault, a boring was driven to some depth, the shaft of the mine under the river proving the same ground, but the seam was not found. It was thus plain that, if a fault, it must have a very considerable throw. Against this, however, some very strong *á priori* reasons were existent. The boundary of the two formations sweeps across the run of this supposed fault without any displacement, showing that the age of the fault (if it existed) must be older than the Máhádévá beds, and on the other hand the constant parallelism of the strata in the two formations, with great steadiness of horizon in the lower group at the boundary, would be almost incompatible with so great a disturbance affecting the lower group only. There is some direct evidence in support of these arguments; in the gallery and the shafts driven beyond the 'fault' in search of the seam, a quantity of hard black sandy clay with thin strings of coal was cut, for which, unless it represent the seam, no horizon could be assigned. I believe then that this is only a fault in the wider sense given to the term by miners of the nature of what is sometimes called a 'horse-back,' a thick drift of sand against which the coal deposit ended. An analogous feature occurs in the new mine on the lower seams; these stop abruptly against an east-west fault, of which a section is exposed in one of the road cuttings, showing certainly some slipping along the crack, but in the position of the seams beyond this small slip there is only found a band of coaly shale and even this dies out within a few yards.

Regarding the exploration of the Satpura coal basin in other regions, I would strongly recommend that efficient trial be made both in the Dudhi and Tawa valleys at some distance from the north boundary of the field. In my detailed geological description of the ground I notice some features which complicate very much the calculation of the depth at which the coal may be cut; indeed any estimate at present without any local precedent to guide one would be no more than a guess. The analogy of other Indian coal fields, so far as known, is altogether in favour of the coal here being within a workable depth. I would recommend Budi, in the Dudhi valley, and the banks of the Suk Tawa, south of Kesla, in the Tawa region, as suitable places for trial borings. An analogous position might be chosen at Bichla on the Sitariva. All these places would be clear of the unfavorable conditions—coarse conglomerates, high dips, and copious trap intrusions—which increase the difficulties of exploration close to the boundary of the field, as has been so unfortunately experienced in the trials made by the Narbadá Company; the borings they have attempted to the south have 'come to grief' at small depths in the coarse conglomerate. The only inducement to keep near the boundary there, was to be more or less within known and calculable conditions. In choosing

actual sites for borings in the positions now recommended, the point may be decided entirely with reference to the convenience of surface conditions for the operation, the geological data being so vague as to leave the exact point immaterial within a considerable range; only, give a wide berth to trap dykes.

The discussion of last season's observations on the north boundary of the Satpura basin has led to an inference of the possibility of coal being found in the Narbadá valley itself. Shallow borings through the alluvial deposits would show whether these were underlaid by the metamorphics, or by formations belonging to the coal series. I would recommend Gadurwara and Bankeri as suitable positions for this experiment.

H. B. MEDLICOTT.

August 1872.

NOTE ON THE VALUE OF THE EVIDENCE AFFORDED BY RAISED OYSTER BANKS ON THE COASTS OF INDIA, IN ESTIMATING THE AMOUNT OF ELEVATION INDICATED THEREBY, *by* WM. THEOBALD, *Geological Survey of India.*

In a paper in the Records of the Geological Survey, Part 3 of 1872, on the geology of the Bombay Presidency, Mr. Blanford quotes some observations made by myself in 1858, establishing the elevation of a portion of the Kattiawar coast during very recent times, and it is with reference to some of the evidence adduced in support of this assertion, and in order to correct an error caused by misreading of my notes, that I would here offer a few remarks. Mr. Blanford (*loc. cit.*), page 101, makes my estimate of the rise in the coast that took place in 1856 to amount to *ten* feet, a misreading for *two*, the words used by me being as follow:—

"Many of these oysters are seen with both valves attached, and evidently but recently dead; and as oysters of this size are never uncovered, I presume that an elevatory movement of at least *two* feet, and probably more, took place in 1856, the year when all the oysters in the creek were destroyed". Of course a clerical error of this sort is very easily made, and in this instance the actual amount of elevation that took place may in reality have been nearer ten than two feet. The evidence, of course, of the occurrence of oysters of a sort never exposed by spring tides above low water mark is conclusive, but does not permit a very exact gauge as to its amount. There is, however, another point connected with the question on which I would record a caution. There are on the coasts of India three species of oysters which are likely to be made use of in determining questions of littoral elevation, *viz.*, the creek oyster, the shore oyster, and the rock oyster. The creek oyster is a large species something like the fossil *O. lingula*, Sow., and possibly, Dr. Stoliczka thinks, identical with *O. Talienwahensis*, Crosse, and attaining occasionally the length of a foot. It is excellent eating and universally esteemed, but it is only procurable at the springs, as it rarely occurs in less depth than a little below lowest spring tides, and never, as a rule, above that level.

The second species is, in my opinion, merely a variety of the last, and Mr. Hanley, to whom I submitted specimens, declared they were barely distinguishable from the European *O. edulis*, L. This species occurs sporadically between tide-marks both on the coast of Kattiawar and the eastern shores of the Bay of Bengal, in common with both the other species, and from its sparse mode of occurrence is, in my opinion, merely an abnorma form of the first, reduced in size and altered in appearance by the uncongenial surrounding amidst which it has been developed. A specimen collected by myself of this form is figured as *O. nigremarginata*, Sow. in Conch. Iconica, Plate XXXIII, 84. The third species is the little

slipper oyster *O. cucullata*, Born, which is seen crusting every surf-beaten rock wherein little else save a limpet or barnacle could make good their hold. This oyster is eaten largely, and is generally wholesome, but as it occurs in creeks and spots where it becomes subjected to very unnatural conditions a little caution should be exercised, as under circumstances it becomes, I believe, unwholesome. In places exposed to the open sea and the roll of the breakers, it would seem to flourish vigorously anywhere between tide marks, but in more sheltered spots its proper range seems to be lower, although its vitality is such that there seems to be no spot to which the fry can gain access, whereon they will not grow to maturity. As an instance of this I will mention one case on the Arakan coast, where I noticed this species growing at the extreme (neap) high water level; indeed I may say above it, where the oyster could never have obtained two hours continuous immersion at any time, and that only during a few days in the month whilst for many days together it must have remained with its valves closed. The spot where this was noticed by me was a small island off the coast on its sheltered side. The rocks were sandstone and there was no shelter from the sea. I landed at high water (neaps), and the oysters I saw along the margin of the water were, it seemed to me, dead judging from that position. On knocking off one, however, with a hammer, I found it was alive, and on putting it into my mouth remarked that it felt unpleasantly warm. From this we may draw the conclusion that in investigating a raised beech or littoral tract the evidence afforded by the presence of the small *O. cucullata* only reaches conclusively to demonstrate the difference between the spot raised and *high water* mark, and that without additional evidence no greater amount of elevation can be deduced therefrom; whilst the presence of the larger creek oyster in any raised deposit may be held to establish the elevation of the spot it occupied to the full amount of the interval between it and *low water* mark. In all accounts, therefore, wherein oysters are recorded as raised, it is very important to obtain specific information as to *which* oyster is meant, the difference involved in the discrimination amounting to the entire height to which the tide rises in the locality in question.

NOTE ON A POSSIBLE FIELD OF COAL MEASURES IN THE GODÁVARÍ DISTRICT, MADRAS PRESIDENCY, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

About twenty miles to the westward of Rájámahindri there is a great area of brown and red *Kámthi* sandstones, &c., which was very rapidly examined and subsequently described by Mr. W. T. Blanford.* One of the desiderata of this examination was to ascertain if any further indications of underlying coal-bearing rocks existed than those already known on the Godávarí river, but Mr. Blanford was only successful in finding a small field of these, to which he refers as follows:—"In only one place was any rock seen which had a distinctly *Barákar* character. This lies south of the village of Bedánol, nearly due east of Ashraopetta, in a stream, and even in this case the rock was only white felspathic grit unaccompanied by shale or any other typical *Damuda* formation."

During the latter part of the working season just concluded, I have had an opportunity of going more closely over so much of Mr. Blanford's area as lies within the Godávarí and Kistna districts, but still without having found any other locality than the one pointed out by him. Neither could I, here, find any trace of coal, nor is there any knowledge in the neighbourhood of its ever having been seen. There is yet, however, the possibility of a seam being found by closer search, considering that there are in the stream

* Rec. G. S. of I., 1871, page 4, 1872, page 1.

courses numerous sand-filled gaps between outcrops of rock which may be scoured out differently every season and may thus show coal which we have missed*.

The absence of shale, as noticed by Mr. Blanford, is not necessarily of material consequence, as local experience shows, for no shales are exposed in either the Singareny, or Pungady Vagu (Kamárum, Nizam's dominions) fields, the coal seams in both cases being sharply interstratified with sandstones.

This being, up to the present, the only known locality in the Madras Presidency Proper of sandstones belonging to the Indian coal-bearing rocks, it possesses more interest than it possibly deserves from the small extent of the field and absence of any absolute indications of coal. On this account, as well as because it may be found advisable to try the field by boring, the following short details are given.

The field of these Beddadanol beds is about 5¼ square miles in extent, being situated on the head waters of a large feeder of the Yerra Kalwa, with the village, or rather few huts, of Beddadanol in its midst. It is some thirty-eight miles west-north-west of Rájámahindri, and about four miles or so from the boundary of the Nizam's dominions near Ashwarowpetta. The nearest large village, Gunnapawarum, lies a mile and half to the south. The area of sandstones is itself covered by thick tree-jungle and very thinly populated.

The strata extend for some width on either side of the river; on the left there is a width of little more than a mile, with a length of something more than four miles, while the patch is narrower on the right, being about a mile wide in the middle and thinning off to the north and south. The rocks are thick and thin bedded, coarse felspathic sandstones, rather friable, of white or pale grey and buff colors, weathering much darker. They occasionally exhibit ferruginous concretions on the weathered surface like the sandstones of the same group at Lingála on the Godávarí. Generally, the resemblance to the sandstones of the Singareny coal-field is most striking. The dip is, as a rule, south-west or westwards at low angles of 2°, 5°, 10°, and there are occasional undulations.

In the small stream south of Beddadanol there is a tolerably continuous outcrop of sandstones, having a general dip of 2°—5° to south-west, with frequent easy rolls all down the bed until it debouches on the main stream. Very much the same kind of section is seen up the nullah north of the village, and again in a side stream further north. In the main river there are frequent outcrops of these sandstones below the junction of the first feeder mentioned above, and away in the jungle on either bank: but the best outcrops are seen higher up at the watering place north-west of Beddadanol, and thence upwards along the river course. Here there is a good deal of sandstone displayed on either side of the stream in thick beds, having an easy dip to the west. These are overlaid by a more compact and hard brown bed which seems to mark the change upwards into *Kamthi* beds, as it is succeeded by thinner yellow strata, and then by the red purple and brown beds so characteristic of that series in this part of the country.

It is very difficult to estimate the thickness of the *Barákars* as developed in the area under notice, owing to the frequent rollings of the strata; but as far as could be made out on the three stream traverses of the Beddadanol side of the field, there must be at least 300 feet without reckoning the strata on the other side of the river which are not at all so clearly seen.

* As an instance of the rarity of exposure of coal seams, the case of the Singareny (See Rec. G. S. of I., vol. V., part 2) coal field may be cited, the seam having only become exposed by the merest accident of the water in the stream being so low.

To the west of the field, the land rising to the low flat-topped hills of Perrumpoodee, &c., is all made up of *Kamthis,* under which the Beddadanol *Barákars* may extend for any distance, though they will—if such be the case—be at too great a depth to justify mere trial boring, unless some better evidence of coal can be obtained from the sandstones now exposed. Along the eastern edge of the field the strata are lying directly on quartzose gneiss, without any interpolation of *Talchirs.* Indeed, around the edge of the whole of the area in the two districts now referred to there is no occurrence of these latter rocks; the *Kamthis,* except in Beddadanol neighbourhood, resting on *gneiss.*

On the whole, it is very much to be feared that there is here only a small patch of *Barákars* which does not extend far under the *Kamthis*; so that, if coal were eventually struck, the quantity would be so small as to be merely sufficient for local use. According to all the observations and conclusions of my colleagues who have worked at the coal rocks of India* it seems pretty clearly established, that the *Damudas,* so extensively developed in Bengal, became of less and less importance to the west and south-west, the Raneegunge beds eventually being entirely absent or represented by rocks containing no coal, until there was only a series of small outlying basins of the lowest group or *Barákars* deposited on the lower part of the Godávarí valley which now remain as the coal-fields on the Pungady Vagu (Kamárum) and at Singareny, and last the sandstones of Beddadanol. On the other hand, the *Kamthis,* considered to be in part at least representative of a higher series *(Panchet)* have thickened out greatly in this direction, and constitute the great area of sandstones to the north of Ellore and west of the Godávarí; which have in no case been found to contain coal.

There may, of course, be other patches of *Barákars* under this spread of *Kamthis,* but it would be working on mere chance, and at a most enormous cost, to attempt to pierce at random through this thick series on the expectation of striking on any hidden coal store. The succession of these *Kamthis* is so clear one bed under the other for the whole distance across the strike from south-west to north-east, at a varying dip of 5°, 10°, 20°, to the south-west, without once a sufficient undulation to bring the bottom beds nearer to the surface than they can be struck along the north-east edge of the field, that all borings would run to an enormous depth. The only locality where at one time there appeared the slightest chance of finding lower beds brought nearer to the surface was in the Ponakamaud Station range of hills, about 24 miles due north of Ellore, but it was soon found that the strata on the north-east slopes of the range were still underlaid by many hundreds of feet of beds of the same series.

Nevertheless, the finding of coal in the Madras Presidency is of such vital importance that it seems advisable to have a series of borings made in the Beddadanol field. A very few trials, and these of no great depth, possibly not more than 300 feet at the most—and even this depth could to a great extent be avoided by putting short bore-holes down in a line across the strike—would settle a question liable to crop up continually so long as it was believed that sandstones of the coal measures existed in the Godávarí district which had not been explored in this way. Boring tools could probably be obtained from the depôts on the adjoining Godávarí works, and possibly competent parties to take charge of the trials.

WILLIAM KING.

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* See Rec. G. S. of I., part 3, vol. IV.

NOTE ON THE LAMÉTA OR INFRA-TRAPPEAN FORMATION OF CENTRAL INDIA, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Recent work enables us to record some fresh observations regarding the formation denoted in the publications of the Geological Survey as the Laméta or the infra-trappean group of Central India. Although never more than from one to two hundred feet in thickness it has a wide range, occurring continuously for great distances along the eastern base of the Deccan trap; from the Narbadá valley round by Amarkantak to the Nagpúr and Chandá country. It is principally of interest for the evidence it may give as to the age of the great volcanic formation with which it is so closely connected. Its position in this question is apparently conflicting, and offers an interesting test of the independent application of palæontological determinations. Examined from the east these deposits would certainly be (and have been) identified with the very similar inter-trappean beds occurring in the adjoining sections; and these have been considered to be Eocene. This opinion was first formed from the *facies* of the fresh water and terrestrial fossils, which are the only organic remains found in these intertrappeans in the upland country; but it has received support from the examination of the few marine fossils found associated with the others in the distant outlier at Rájámahindri near the mouth of the Godáveri. This position is geographically related to that of the upper cretaceous deposits of Trichinopoli; but Dr. Stoliczka has found that the marine fossils of the Rájámahindri inter-trappeans are distinct from any occurring in those topmost cretaceous deposits. On the other hand, examined from the west, up the Narbadá valley, the Laméta beds would be (and have been) connected with the infra-trappean deposits of Bágh and Barwai, and these are cretaceous (Middle Cretaceous according to Dr. Martin Duncan, Quar. Jour. Geol. Soc., London, Vol. XXI, p. 349).

The last discussion of this question was by Mr. W. T. Blanford (in Vol. VI, Mem. Geol. Sur., pp. 156-160 and 207-218, and Rec. Geol. Sur., Vol. V, pp. 88-93), and a strong case was made for the correspondence of certain infra-trappean deposits throughout the Narbadá valley. Mr. Blanford's remarks upon the eastern area were not all based upon his own observations, but partly upon previous work of old date on the Narbadá coal-basin (l. c., Vol II), in which it was conjectured that the Laméta beds on the east might be the equivalent of the Máhádévá sandstones of the Pachmari hills. He was thus led to assimilate the calcareous portion of the Bágh series and the sandstones conformably underlying them to the Laméta limestone and to the Máhádévá sandstone respectively. Recent detailed work has shown that all the rocks known as Máhádévá in the Narbadá region belong to a great plant-bearing series, the youngest member of which is the Jabalpúr (jurassic) group; the Laméta deposits being totally unconformable to this group. This separation of the Laméta and Máhádévá groups is so wide that were Mr. Blanford's conjectural identification of the sandstones confirmed, it would give very strong presumption of the separation of the two limestones; but it was upon the correspondence of these that Mr. Blanford laid most stress; and for them the case stands much as he left it; the stratigraphical break between the cretaceous deposits of Bágh and the trap overlying them being much less marked than the break between the trap and the nummulitics of Súrat and Bharoch. Mr. Blanford was disposed to consider the volcanic formation to be more nearly cretaceous than tertiary. The comparison of the Rájámahindri fossils had not then been made, but Mr. Blanford, to some extent, anticipated the result by saying that "exact specific identity can scarcely be expected, the Rájámahindri band being, I think, estuarine, while all the Trichinopoli beds are purely marine." The separation of the Lamétas from the intertrappeans has not lately been contemplated by any one; Mr. Blanford notices (l. c., p. 216,) how undistinguishable they are lithologically; and,

of course, the confirmation of their close affinity would be a link in the chain of evidence be brought to bear upon the age of the eruptive rocks. Thus the solution of this interesting question seems closely connected with the determination of the correspondence of the Bágh beds and those similar deposits on the same infra-trappean horizon.

The Lamétas, though so much more extensively developed than the intertrappeans, have yielded comparatively few fossils. Vertebrate remains, some very large, have been found in them at Jabalpúr, and elsewhere some shells, establishing the fresh water origin of the group; and so far, its *primâ facie* connection with the intertrappeans. One would then naturally go on to apply the same explanation to the formation of this fresh water basin as that given by Mr. Blanford for the intertrappeans, namely, the stoppage of local drainage by the outflow of trap. This would at once annex the Lamétas to the trappean formation. The great comparative continuity and extent of the Laméta deposits presents some difficulty to this supposition; the conditions would rather suggest some more general cause, such as tilting of the surface, by which the drainage of a large area would be thrown back, and the direct evidence which might be looked for to connect them with the trap is wanting. There is not a single instance known throughout this extensive formation of a bed passing from it over and between trap flows, although it is very common to find trap close to thick Laméta deposits, and at a lower level. This circumstance involves considerations, some of which have an important bearing upon the relations of the two formations, implying, as it does, either (1) abrupt inequality in the Laméta deposits; or (2) considerable pre-trappean denudation; or (3) disturbance of the deposits, whether before or after the advent of the trap. The principal object of the present paper is to illustrate this feature of the case.

The Laméta group is well exposed in the immediate neighbourhood of Jabalpúr. The undulating ground to the east of the station is on the thick soft sandstones and pale shaly clays of the Jabalpúr group; the flat hills beyond being of the Laméta beds, capped by trap. On the little ridge to the north-east of the station, the Lamétas show their greatest development, being about 150 feet thick. The south-west summit of this ridge, locally called Chota Simla, is capped by about 20 feet of trap; and on the north-east, where the Trigonometrical Survey Observatory Station is erected, there is a crest three-quarters of a mile long formed of trap, to a thickness of about 50 feet. This ridge quite overlooks the trappean plateau to the south-east, from which it is partly separated, on the west, by the valley of the Marjadlia stream, cut through the Jabalpúr sandstone, the base of the Lamétas here being close under the steep rise of the ridge. This level is maintained by the junction along the little valley, at the head of which the trap of the plateau rests upon the Jabalpúr group, thus giving a strong case of apparent unconformity, the whole 150 feet of Lamétas disappearing within a distance of half a mile, at the level of the bottom bed. South of the little valley the Lamétas come in again at first only 5 to 10 feet thick, but increasing gradually to the south, the base of the group sloping down under the alluvium in a length of about one mile and a half.

Regarding the junction of the Laméta group with the Jabalpúr beds this section gives apparent presumption of unconformity. It would be difficult to give clear evidence on this point from this locality, on account of the massive irregular structure of the Jabalpúr deposits; and it is evident that such features as those described might be caused by a slight undulating disturbance of two conformable groups, followed by denudation before the advent of the trap. There is, however, ample evidence elsewhere of the discordance of the Jabalpúr and Laméta groups; the latter passing indiscriminately across the former, and even here, at the east base of the observatory hill, an inlier of Jabalpúr sandstone is weathered out from the surrounding Laméta limestone.

MAP of NEIGHBOURHOOD of JABALPUR.

But it is the upper junction that we are now concerned with. For this case the supposition of slight disturbance and considerable denudation of the Lamétas, both pre-trappean, is *primâ facie* suggested by the section described. It is desirable, though difficult, to keep separate the argument for those two operations. If the supposition of disturbance be excluded, thereby leaving the present under-surface of the Lamétas the same as at the time of deposition, it becomes almost necessary to suppose that they extended in greater force than we now find them over the ground to the south, and hence that they were removed before the overflow of the trap; for, it is difficult to imagine how, in a small area, the thickest deposits could be accumulated on the highest ground, much of them being composed of fine sand and clay. It is not either a uniform thinning to the south; for in that direction they thicken again before passing under the alluvium. If we are to explain the great contrast in thickness to the north and the south of the little valley by the presence, at the time of deposition, of a ridge of Jabalpúr sandstone in the position of the present valley, the fact of pre-trappean denudation would be equally established, for the trap now rests on the sandstone, at the head of that valley, at the level of the bottom beds of the Lamétas. If, on the other hand, we explain the fact of the deposits being at present thickest on the higher ground, by supposing a change of level subsequent to deposition, it would be possible to dispense with denudation, and we should be called upon to decide whether the disturbance occurred before or after the out-pouring of the trap. The very rough structure of stratification in volcanic rocks would make it very difficult, indeed, to find conclusive evidence for or against this position. It can only be said that the general distribution of the Laméta deposits suggests a slight relative change of level since their formation; and that the only direct observation bearing upon this point seems to show that the trap did not participate in that movement: at the base of the low scarp east by south of the village of Pachpéri there is a marked apparent dip of the Laméta limestone by which the trap does not seem to be affected; on the contrary, the level is maintained by a thickening of the sand overlying the limestone. This dip is spoken of as 'apparent,' because the original irregularities in the Lamétas are so rapid that one cannot be certain that the feature here was really induced by disturbance.

The internal evidence of the Laméta deposits throws some light upon these general considerations. No constant sequence or composition could be given for the group. A limestone is its only general characteristic; sometimes forming the whole of the band, sometimes quite subordinate in detrital deposits. All these conditions are illustrated at Jabalpúr. At the point of Chota Simla hill, and on the outlier to the west of it, the section is as follows:—at base is a thick, false-bedded, fine, porous, friable sandstone, pale, generally of a green tinge, sometimes a deep glauconite green (but not from green grains), locally purplish and mottled. At top it is much mixed with fine laminated clay, which again passes into earthy, dirty, pebbly, sandy limestone. It is in this bed and locality that vertebrate remains have been found. This limestone is here overlaid by fine crumbling sandy clay, pale purple mottled by green. Sandy layers are frequent, also strings of nodular limestone. The top limestone is a development of this tendency: it is prominently sandy, and is overlaid by sand. The crest of the ridge between the two terminal cappings of trap is formed of this upper limestone. To east of Chota Simla the lower limestones thicken greatly, replacing the bottom sand; and the whole section varies indefinitely. Under the trap on the observatory hill the top sand is well developed; a peculiar rusty, soft, fine-grained rock, quite devoid of earthy matrix; very like a common form of decomposing Jabalpúr sandstone, but quite unlike the usual sands of the Laméta group. This peculiarity makes it very useful in revealing the internal arrangement of the group, as it happens to be pretty generally distributed in this neighbourhood. Thus, on the south side of the little valley of the Marjadlia (see the figured section) there is a scarped terrace formed of a single

strong bed, 10 to 15 feet thick, of Laméta limestone, resting directly on the sandstones and clays of the Jabalpúrs; and upon it rests the trap, forming a second scarp; only at two or three spots one finds between these a remnant of a sand identical with the top bed on the observatory hill. In normally bedded rocks one would *primâ facie* conjecture from such a section that the limestone here was the upper band of the ridge, requiring, of course, for the non-appearance of the lower beds, the supposition of original overlap, with subsequent change of bed. On the ground, however, one cannot resist the conclusion that the limestones facing each other on opposite sides of the little valley are the same band, they so exactly correspond in every character; so that one is forced to account for the discrepancy otherwise, by the absence of all the middle beds of the ridge. The identification of the limestones on opposite sides of the valley, and their exact correspondence in level, sets aside the introduction of any abrupt change of bed at this point, so that the difficulty at first brought to notice of supposing the original dying out of such deposits as those of the middle beds of the ridge meets us now within the Laméta group itself; and the contrast of thickness and of level is so great that one has to suppose a contemporaneous denudation to have assisted the irregularity of deposition, so as to admit of the top and bottom beds of the group coming together within such a short distance; a general undulating disturbance having still further increased the apparent anomaly of the actual features.

The considerations stated in the last paragraph, by bringing the chief discrepancy within the group itself, would seem to dispose of the main point at issue—the unconformity of the trap on the Lamétas. But such is not the case, even for the particular section under notice. The top sandstone is in force on the observatory hill, and again so to the south of the Pachpéri flexure; and it continues so beyond the Marjadlia valley to the south-west. On the Pachpéri terrace, however, between the two first of these localities, one finds the nearest remnants of it, and this only locally between the trap and the limestone. Its absence is most reasonably accounted for by denudation.

There are some local sections near Jabalpúr independently involving the conclusion of a pre-trappean denudation of the Lamétas. The ridge on which the European hospital stands is formed of Laméta limestone. In the river, a quarter of a mile to the east, the limestone associated with mottled sands reaches from the water's edge to some 50 feet on the hill-side. In both positions there is a capping of trap; but between the two, on the north face of the rising ground, the trap reaches to a lower level. Again, in the reverse valley, to the north-east of the Marjadlia water-shed, the trap reaches nearly to the stream on the south-east side, at a much lower level than the Laméta limestone within a few yards of it on the north-eastern spur of the observatory ridge.

The views illustrated in the foregoing remarks upon the sections at Jabalpúr are briefly these: that the Lamétas are clearly pre-trappean; that there is good evidence for a slight pre-trappean disturbance of that group; and, that there is conclusive evidence for pre-trappean denudation.

The local denudation of the Laméta group would not be of much significance as an indication of any partial separation of it from the trappean formation; for, as Mr. Blanford has himself shown, the inter-trappeans have also suffered denudation before their inclusion by the trap. Mr. Blanford indeed, did not propose any separation of the Lamétas from the inter-trappeans, but rather, through their connection, to establish the cretaceous, rather than the tertiary age of the trappean formation; the correspondence of the Lamétas with the Bágh beds being the point he most insisted on. And, certainly, the petrographical homology of these groups is very striking. The considerations here offered tend to confirm that identification.

The denudation of the Lamétas seems to have been much greater to the west than to the east. From Jabalpúr they can be traced continuously for great distances round the Mandla plateau. That so moderately thick a formation should be so unbroken proves, at least, that the basin in which it was deposited was not there laid dry for any considerable period before the advent of the trap; if it does not indeed establish a closer connection with the volcanic outburst. It is very different to the westward: in going along the Narbadá valley gaps become more and more frequent, and of greater length. In most of these cases it is demonstrable that the deposits are only denuded remnants, the volcanic rock frequently appearing close by at a lower level.

The most westerly occurrence of these patches of Lamétas—that can, at least, be included with the main area of that formation, there being a break of 130 miles on the south side of the valley between it and the infra-trappeans of Punása and the Dhár Forest—is deserving of special notice for the peculiarity of its position, and because large vertebrate remains, though scarcely perfect enough for identification, have been found in it. It is not even quite certain that it is Laméta, because the supporting rock is not visible; but the lithological characters are so marked as to give much confidence in the identification. It forms a small inlier, weathered from beneath the trap in the bed of the Shér river, under the village of Karcia. There is a deep pool in the river, on the up side of which massive trap forms a steep fall; while on the down side of the pool, twenty yards across, these Laméta beds rise abruptly, having a small dip down stream. The trap appears in the bank above them, resting on a highly baked red sandstone, the top surface of a greenish earthy rock, which is confusedly associated with a more ordinarily pebbly sandstone and with a sandy pebbly limestone; a total thickness of about 15 feet. Within about fifty yards the trap again occupies the bed of the river, and some eighty yards lower down the water cuts a narrow gorge through massive Jabalpúr sandstone, for about two miles. The crossing trap seems to be part of the same mass as that facing the strata on the opposite side of the pool: thus implying a steep face of denudation. If this patch of Lamétas was ever continuous with the main area, it must have been through valleys now filled up by trap, for it is separated from the present Narbadá valley by a broad raised area of Jabalpúr sandstone. In this region the Lamétas do not intervene between the trap and the Jabalpúrs, even at very small elevations.

If it be assumed that these patches of Lamétas are indeed remnants of a once continuous deposit, this feature of denudation in the western region becomes a very important one. At present I see no escape from that conclusion: these patches are all on the same approximate horizon, and there is in most cases no assignable reason for their original limitation as local basins. The suppositions of once intervening marks of older rocks would equally prove the great denudation. I think, moreover, we are hardly at liberty to suppose these local basins to have been determined by intervening trap-flows, for the reason already stated, that no single case has been observed of Laméta beds overlapping, however steeply, on trap.

It is important to notice a precaution that must obviously be taken in applying this crucial test of the pre-trappean horizon of the Laméta beds. The Deccan trap is found in different regions of its very extended border resting upon metamorphics or other old formations at every level, from the moderate elevation of the Narbadá valley up to the highlands of the Western Ghâts. Its local base must, therefore, be presumed to be of different horizon in the formation at these different localities. It must so happen that on the horizon of the inter-trappean deposits, these should occasionally lap freely over the trap, on to the adjoining rocks; and they would, moreover, in such positions assume the sandy, pebbly character so common in the Lamétas, and so rare in the strictly inter-trappean basins.

There though locally infra-trappean, these beds would, of course, belong to the inter-trappean horizon. In his sketch of the Geology of the Bombay Presidency (Records, Geological Survey, Vol. V, page 93), Mr. Blanford notices some cases of this kind, as observed by Mr. Foote in the Kaladgi and Belgaon districts. The fact that in these exceptional positions the deposits contain the usual fossils of the inter-trappean beds only brings into greater contrast the prevailing absence of such remains in the much more largely developed deposits of the Laméta group; and also the occurrence of these overlaps in the comparatively restricted inter-trappean deposits gives some warrant to the demand for their production in the case of the widely extended Lamétas before these can be accepted as cotemporaneous with the trap.

August 1872.

A BRIEF NOTICE OF SOME RECENTLY DISCOVERED PETROLEUM LOCALITIES IN PEGU, *by* W. THEOBALD, *Geological Survey of India.*

In the third number of the Records of the Geological Survey for 1870, a brief notice is given by me of the occurrence in Pegu of petroleum at the then newly discovered locality of Pudouk-ben near Thaiet-mio. Since that date two other localities have been the scene of a not unsuccessful search for petroleum, the main facts connected with which I will here review.

The first locality visited by me is situated eleven and a half miles west of Prome Pagoda in a small stream falling into the Boogoo river, and three miles above the village of Toung-bo-ji, on the same small stream, which has no name applied to it on the published maps, but is locally known as the Mahu-choung.* This spot lies within the area of the unaltered nummulitic rocks, and is situated in a belt of undulating jungly ground, characterised by a general absence of water, and wherein, consequently, no villages exist, the scarcity of water appearing to depend on the impermeable character of the clays, which here mainly form the surface of the country. No good section of the beds is seen between Prome and the Mahu-choung, and the passage from the impermeable clays of the newer tertiaries to the similar beds of the nummulitic group is obscure and unindicated on the jungle clad surface of the ground by any obvious physical sign. The cause of this is the absence here of the nummulitic limestone, the highest member of the group, and, where present, an excellent horizon for the newer group; but this rock has here died out, and in default of good sections, the boundary of the two groups is thereby rendered indistinct.

The petroleum was first detected by some squatting families of Cutch-boilers, who settle in this arid tract as long as surface water is procurable in the small pools and watercourses in it, and these men remarked that in some spots where the water was very low and on the point of drying up, it possessed a flavor of petroleum. The presence of petroleum was, I am informed, noticed as a film on the water, where a dam had been thrown across the Mahu-choung near the village of Toung-bo-ji, below the spot where petroleum has since been obtained.

An enterprising and intelligent Chinaman possessed of a little capital determined to test the value of these surface indications, and sank some shafts along the course of the stream and on a line having an east by north bearing of less than one hundred yards in length. The most promising shaft, No. 2, was sunk in the bed of the stream, which was artificially deflected round it, and was carried to a depth of over 40 feet, through light-

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* *Choung* = river or stream.

bluish clays containing Foraminifera *(Triloculina* or some allied form), but few other fossils, and evidently an homogeneous deposit formed in still water. The clay has not been pierced by the shaft, and, though yielding petroleum, does not appear to be the source or mother bed of it. I judge then from the petroleum appearing to line cracks and interstices in the clay rather than to be disseminated through it, as may be seen by fracturing the larger pieces, which, though superficially imbued to a small extent, do not seem to be equally permeated by it throughout, that it seems probable that the true naphthagenous beds of the group have yet to be reached. Into this shaft petroleum trickled at something like two gallons a day, till it became filled with water and was abandoned during the monsoon.

It may at first sight seem a curious thing that no more petroleum escaped into the shaft after it had become full of water; but I think a sufficient explanation of this lies in the mode of stowage of the petroleum in the rock. The oil occupying minute fissures or partings in the clay escaped by mere gravitation into the shaft as long as it was kept clear; but became at once arrested in its course, and, so to say, ponded back when met and opposed by the pressure of a column of water of 40 feet.

I have since heard that the shaft has been re-opened and deepened, and that thereon the petroleum recommenced to flow, but the ultimate results of the experiment I am unable at present to ascertain.

Bau-byin.

The second locality near the village of Bau-byin (Pau-fyeng in map) is situated some twelve and a half miles west-north-west from the circuit house at Thaiet-mio, and about a mile above the village, which is on the banks of the stream, which falls into the Irawadi a little above Thaiet-mio. It is moreover distant about four miles north-east of the Pudouk-ben locality, previously noticed in the Records for 1870.

In the neighbourhood are several spots where indications of petroleum occur, all in beds of the newer tertiaries and on pretty much the same horizon therein. Bluish shales are the predominant beds here, interspersed with sandstones; and fossils are not rare throughout of the ordinary aspect of the fossils of this group, sundry species of *Arca*, *Pecten*, *Isocardia*, *Ostrea*, *Solen*, *Cypræa*, *Conus*, *Turritella*, with crustacean remains and shark's teeth, having been procured by me in the vicinity.

In the stream about a mile above the village, the blue shales are exposed in a steep bluff undercut by the river, and a brown colored patch near the level of the stream indicates the extent to which the infiltration of the shales by petroleum has here reached. A little below this point a feeble escape of petroleum takes place into the stream from an orifice at about its ordinary dry season level. Close to this point a bed of sandstone with a dip of 70° south comes in, demonstrating a somewhat abrupt downthrow of the shales, which higher up stream are gently undulating, and the presence of this bed has not improbably determined the escape of the petroleum at this point, by opposing an obstacle to its upward progress, or permeation.

A shaft was sunk on the precipitous bank of the nulla, and a little petroleum obtained from it, but the site was bad, as it is scarcely possible to prevent the stream from cutting away the bank and destroying the work. About half way between the banks of the stream on the curve, I recommended a trial shaft should be sunk, the selection being made with reference to the position of the presumed extension of the bed of sandstone noticed above, which it seemed to me undesirable to try, but beneath which a certain supply of oil may be with some confidence looked for. Its escape into the stream, and its diffusion among the shales a little higher up the stream, with other indications at no great distance, render a

search for the oil here rather less a matter of speculation than is usually the case. One thing is remarkable, and that is, on the supposition as advocated by me, that the naphthagenous beds are members of the nummulitic group. A great thickness of beds, not perhaps less than 2,000 feet, must be interposed between the source of the oil and its point here of natural discharge. These beds are more or less porous, and may hereafter possibly prove sufficiently rich in petroleum for profitable working, or possibly for purposes of distillation, but nothing but an experimental shaft will satisfactorily settle their economic value.

The petroleum from the above localities is very similar and more fluid than the commercial or Yenan-choung oil, a difference depending, probably, more on the length of time either has been exposed to the air than on any difference in chemical constitution, but no exact analysis has yet been made.

Correction regarding the supposed eozoonal limestone of Yellan bile.
See Rec. G. S. of India, Vol. V, part 2.

Specimens of this limestone were sent home to Professor William King, Sc. D., of Queen's University of Ireland, for examination, which has resulted in the opinion that there is no eozoonal structure evident. Dr. King states that the rock consists of layers of two or more silicious minerals, and others containing calcareous matter; the former being in general the thickest and most abundant. The silicious layers are of a pale dirty green color. Examined with a good magnifying power, they are seen to be made up of rough grains of grey quartz and flattened particles of a greenish amorphous substance which appears to be chemically related to some amphibolic mineral; both kinds are generally compacted together by themselves, but occasionally calcareous matter is intermixed with them. Here and there the layers are reddened with an iron oxide. The calcareous layers, of a dark bluish green color, are charged with the prementioned grains and particles, principally the latter, and often to such an extent as to become essentially silicious. "In all cases the calcareous constituent is in the amorphous condition, neither saccharoidal nor crystalline, resembling that of ordinary blue-grey limestone.

"Examined after decalcification, the microscope shows the silicious layers intact except where they contain calcareous matters; in this case the component grains and particles, instead of being closely adherent, are separated by interstitial vacancies. The calcareous layers which are etched out to a slight depth exhibit a large number of the green flattened particles, and usually a smaller number of the quartz grains standing out in relief in the undissolved portion, and generally lying lengthways and parallel to the silicious layers. The components of the latter layers also affect a parallel arrangement.

"The rock, strictly speaking, cannot be called metamorphic. It resembles in texture some of the imperfectly developed gneissodes common in Connemara. The thickly laminated portions have all the appearance of being depositional in their origin. But often there are thin laminæ folding round nuclei, seemingly concretionary, which appear to be the result of supervened agencies. It was a specimen of the rock in the latter state that was decalcified.

"The interlamination of the silicious and calcareous mineral substances, as observed by the unassisted eye, and its resemblance to a similar peculiarity present in certain specimens of *Ophite* from the Grand Calumet, Canada, and which alone first gave rise to the supposition that it represented a fossil, have evidently suggested the same idea in connection with the Yellanbile rock; but diligent observation with the microscope does not bring out the least trace of anything approaching to the so-called 'canal system,' or 'nummuline layer,' diagnosed for Eozoon."

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RECORDS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. VI.

PUBLISHED BY ORDER OF HIS EXCELLENCY THE GOVERNOR GENERAL OF INDIA IN COUNCIL,

UNDER THE DIRECTION OF

THOMAS OLDHAM, LL.D., F.R.S.,

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1873. **[February.**

Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1872.

During the twelve months of 1872 our working staff was diminished in number by the absence, either on leave, or on special duty elsewhere, of several of the officers of the Survey.

As stated in last year's report, Mr. W. T. Blanford was deputed to accompany the Boundary Commission in Beluchistan and Persia. Two very interesting papers on parts of the Persian Gulf and of the shores of Arabia visited by Mr. Blanford, while waiting for the arrival of his fellow labourers, have been given to the public during the year. Later on, at the close of the boundary labours, he was compelled by ill health to proceed direct to Europe, where he arrived in September. It is to be hoped that he will be able to work up the extensive and valuable materials he has acquired, together with those of his colleagues in the duty. Taken as a whole, it is certain they will form one of the most valuable contributions to the Natural History of a little known portion of the earth's surface, which offers many points of high interest and importance, in so far as it forms a connecting link, as it were, between our Indian empire and the wide areas of Arabia on one side and of the Caspian and Russia on the other. Mr. Blanford also had opportunities not often offered to European naturalists, which, I doubt not, he made ample use of. On this duty he has been absent during the whole twelve months. Mr. Foote was absent for three months from August to November. But this interfered only slightly with the progress of the work. Mr. Fedden, who had been suffering from frequent attacks of fever in the unhealthy district of the Pemgunga and Wurdah valleys, left the country on sick leave in May, and has been absent since. Mr. Hughes, who had been invalided in the same districts during the working season of 1871-72, returned to duty and resumed his work in November 1872, and has since been actively engaged. Dr. Waagen was also compelled to leave for Europe on medical certificate at the close of the year. Mr. J. Willson, who had been absent on sick leave from May, resumed his duties early in December, and at once proceeded to the field. These constant changes, necessitated in a great measure by the heavy work and great exposure to which the assistants of the Geological Survey are subjected, unavoidably retard progress and delay the completion of maps.

At the commencement of the year (January 1872), Mr. Medlicott was actively engaged in the examination of the Satpura coal-fields and adjoining country. Some of the results of this examination are already published. Of these results the most important, practically, were two—the possibility of coal being found to extend under the more recent deposits of the Narbada valley proper outside the hills, and the probability of beds of

workable coal being traced more to the south in the Dudhi valley. To test the former, Mr. Medlicott recommended that boring trials should be made near Gadurwarra, and this has been commenced. The actual borings have been placed under the charge of Mr. Collin, a coal engineer who had been engaged at Wurrora in the Chanda district. But badly supplied with tools, and at a distance from any place where mechanical appliances and instructed labour could be obtained, the progress hitherto has been very small and very disappointing. Mr. Medlicott is only responsible for the proper selection of the locality, the actual working being under different control. The false economy of attempting to carry out such an undertaking without proper tools and efficient supervision cannot be too strongly insisted on. Mr. Medlicott meanwhile has been endeavouring to push on the geological examination of the adjoining country, this being the necessary preliminary to any further practical search for coal, his progress in this being, however, most seriously retarded by the necessity of looking after boring operations so inefficiently conducted, without any countervailing advantage.

Mr. W. L. Willson has been steadily engaged in extending the geological lines and boundaries, from the north of Dumoh, where he had been engaged, into Bundelcund and the adjoining territory of Rewah. The district examined is as yet incomplete in itself, and any description must be deferred. Mr. Willson was, during the recess, most usefully employed in the preparation of the maps of Dumoh district on the scale of 1 inch = 1 mile for publication, some of which are now ready.

Mr. Mallet, who had, as reported at the close of last season, proceeded to the coal-fields of Kota, on the southern borders of Mirzapúr district, mapped out its limits. He notices some fourteen outcrops of coal, most of them, however, very thin and worthless; some two or three have a workable thickness of fair coal. All appear to be on about the same horizon, not more than two being seen in any cross section, the richer outcrops thus appearing to be only local. Mr. Mallet has also added many interesting mineralogical observations to those in his previous report upon the rocks occurring in the widely spread gneiss series, especially upon the valuable bed of Corundum which he had noticed in that neighbourhood. These notes having been published in the Memoirs of the Survey need not be alluded to here more particularly. During the later part of the year, Mr. Mallet has taken up the examination of the Hazaribagh district. A considerable part of this district had been gone over some years since, but the topographical maps, which were then available and which were shortly afterwards condemned, were so imperfect, and those resulting from the re-survey so entirely different, that it has not been found practicable to transfer the geological lines, &c., without absolutely going over the ground a second time. Mr. Mallet's labour will be confined chiefly to the crystalline and metamorphic rocks. In a similar way, Mr. James Willson has been, since his return from sick leave, engaged in putting in the geological boundaries and divisions of the coal-fields in the south of the same district on the new maps preparatory to publication.

In the early part of the season, Mr. Ball was engaged in the examination of the coal-bearing rocks in Sirguja. Among these areas, the small coal-field of Bisrampúr is in itself complete, and will shortly be published. Among these rocks Mr. Ball has noticed a case of unconformity between the lower group, or the Barakár rocks, and the upper sandstones, defined by faulting in the lower rocks not affecting the upper. This is a very unusual occurrence, but is of high interest if established by further research.

In the latter part of the year, Mr. Ball has been deputed to accompany Mr. H. Bauerman, who had been sent out by the Right Hon'ble the Secretary of State, in his visit to the more important iron-yielding districts, with a view to giving a definite opinion on the feasibility of establishing iron works in India, and with him has visited

Birbhúm, Raneegunj, Hazaribagh, &c. Mr. Bauerman's report will be submitted to the Secretary of State.

Mr. Hacket has carried his lines and divisions from the adjoining districts of Jabalpúr and Bijiragoogurh into Rewah. A very large part of this area is covered by the Jabalpúr formation. It is seen typically in the north-west of the area, but is extended by Mr. Hacket considerably to the south of Bandogurh. The Bandogurh sandstones are themselves 1,000 feet thick. How far this apparent extension of the formation can be proved to be the fact must be seen from the adjoining country when it comes to be examined. In the present season Mr. Hacket has been sent to work out the details of the more recent deposits of the Narbada valley in connection with the Satpura basin, which Mr. Medlicott is examining at the same time.

Previously to his departure on leave, Mr. Fedden had extended to the south his examination of the rocks of the Nizam's territories adjoining Chanda, tracing out the existence of a group of rocks under the great Deccan trap to west of Sirpúr, containing remains of *Palæozamia*, thus establishing their relations with the upper jurassic rocks of Kutch and the Rajmahal beds of Bengal, and giving another clue towards unravelling the connection of the so-called Jabalpúr beds of the Narbada valley with the others. The full extent of these rocks remains to be worked out.

In the Punjab, at the opening of the year, Mr. Wynne and Dr. Waagen were engaged in the detailed examination of the Salt-range and adjoining country. This has enabled the mapping of the whole of that range to be completed, while a remarkably interesting and extensive series of fossils has been obtained, which have as yet been only partially examined, but which, when fully investigated, promise to open up some very important and intricate results. One of these discoveries I will notice again. At the close of the working season, Dr. Waagen returned to Calcutta and took up the detailed examination of the Cephalopoda from Kutch, our previous collection of which had received very extensive additions from the labours of Dr. F. Stoliczka. This group will form one of the most important contributions to the Cephalopoda fauna of the upper jurassic formations (from the Tithonien to Callovien) ever published. The extent of this group alone, without any of the other classes of Mollusca, may be estimated from the fact that their illustration will require about 60 large quarto plates. The MSS. of the descriptions have been nearly all completed, and great progress has been made in the preparation of the plates. But it was with much regret that we were obliged to suspend the work,—only temporarily, I hope,—in consequence of the serious illness of Dr. Waagen, who had commenced it, and whose wide and accurate acquaintance with the Cephalopoda rendered his descriptions highly valuable. I sincerely trust that a few months and a better climate may restore Dr. Waagen to the enjoyment of full health, and enable him to resume and complete his history of this most interesting fauna.

Towards the close of the year, Mr. Wynne had resumed his examination of the Punjab rocks, but was necessarily diverted for a time to enable him to aid in procuring and forwarding a complete collection of the salts and rocks of the Salt-range and its salt mines, to be sent to the Vienna Exhibition. Having accomplished this, he resumed the detailed examination of the country north of the Salt-range. A brief but careful description and sections of the well known hill of *Sirban*, close to Abbottabád, has been published during the year—a result of the joint labours of Dr. Waagen and Mr. Wynne. This has been given without delay, both because the hill is close to a well known station, and so accessible to those who desire to examine its structure, but also because this structure had been entirely misrepresented; while it would at the same time form a typical illustration of what might be looked for in other similar areas.

In Madras Mr. W. King had, at the commencement of the year, taken up the examination of the country adjoining the Godávárí, in continuation of the preliminary survey of the same area which had been carried out by Mr. Blanford, whose health did not admit of his returning to that district. As it was important that the more southern portion of the country should be carefully examined prior to proceeding to the less accessible area further north, Mr. King's attention has been chiefly directed to the country extending between Dumagudiem and Kummummett. Some of the principal results arrived at have been already published in the Records of the Geological Survey for 1872, so they need not be detailed here. In one place, a limited area of coal-bearing rocks was traced out, and actual beds of coal found; but the country is so covered with jungle, and so thickly coated with debrís and recent deposits, that nothing very definite can be asserted regarding the extent or value of this coal without borings. Another small area near Ashwarowpetta holds out some promise, but this also must be actually tested before any satisfactory conclusion can be arrived at. Towards the close of the year, when it was too early in the season to enter the jungly country to the north with any safety, Mr. King has made a careful examination of the country between the Godávárí, and Rajahmundry, and the sea, an l has there found some fossiliferous beds, the organic remains from which will prove of high interest. He has also brought the well known fossiliferous beds of Kateru, near Rajahmundry, into stratigraphical relationship with those occurring at Pungady on the opposite bank of the Godávárí—here a stream of great width. As the jungles become drier and more accessible, Mr. King will extend his researches northwards.

Mr. Foote has been steadily carrying out the boundary lines between the great area of the Deccan trap rocks and the underlying beds; and between those intermediate beds and the gneiss rocks on which they rest. He has connected his lines with those previously mapped in by Mr. Wilkinson to the west. The entire area examined, excepting a few square miles on the top of the plateaux, is within the drainage basins of the Kistna, Gatpurba, and Malparba rivers. Mr. Foote has also been fortunate enough to add to the valuable series of fossils, bones, &c., of *Rhinoceros*, which he had obtained during the previous year, and to find others of bovine animals, together with deposits of fresh-water shells, which on examination proved to be very similar to those found with the ossiferous clays and gravels of the Narbada valley. There can be no question that these ossiferous beds will prove of the very highest interest when fully worked out, as bearing on the distribution of genera in these pleiocene deposits, which still exist in other areas, but which have entirely ceased to exist within the limits of the districts where their remains are found.

In Burmah, Mr. Theobald has been engaged in extending his examination of the country between the central range and the eastern boundary of the country on the Sittang river. The present season will see the completion of his examination of British Burmah proper; and a map and general report will then be prepared for publication.

Dr. Stoliczka, in the early part of the year, completed his detailed examination of the Province of Kutch (Kach'h), in which he has been enabled, by the application of his palæontological knowledge, to define several well marked sub-divisions or horizons in the jurassic rocks, and to establish their close relationship to the acknowledged groups in European classifications. The full details of these are being prepared for publication, while the magnificent series of fossils also obtained will be worked out as soon as possible.

PUBLICATIONS.—The RECORDS OF THE GEOLOGICAL SURVEY OF INDIA have appeared with regularity at the established three-monthly intervals. In the series for the past year, besides the Annual Report of the Survey, papers, more or less in detail, have been given, treating of very varied subjects and localities. It would have been impracticable for a

considerable time to come to publish a detailed account and map of the complicated structure of the hills flanking the great Himalayan range in the Punjab; and it seemed, therefore, desirable to give at once a brief outline and description showing the relations of the rocks and their general physical aspects and structure.

For this purpose, a section close to the most frequented station in those hills, Murree (Mari) was taken. Dr. W. Waagen has pointed out very clearly the distinctions of the beds, as indicated by their fossils. Such a sketch ought to suffice as an index or guide to other observers in the adjoining districts. Descriptions of the mineral contents of the gneiss in the district of South Mirzapúr are given by Mr. F. Mallet, who has pointed out the occurrence there of a very valuable deposit of Corundum, which is also of high interest from its associated minerals being identical with those occurring in America in the same association.

The sandstones of the Godávárí are described by Mr. Blanford, while Mr. King, who took up Mr. Blanford's work there, describes in more detail the southern portions of this area near Kummummett, and shows the occurrence of coal there in quantities which will repay the expense of working when the field is rendered more accessible. Mr. Blanford also contributes two valuable sketches of the geological structure of the Beluchistán shores of the Persian Gulf, as well as a notice of Maskat and Massandim on the coast of Arabia. Mr. Medlicott describes in detail a very remarkable case of what appears to be only local jointing in some sandstones at Jabalpúr, and a careful discussion of the physical relations of the 'Lameta' group. Mr. Theobald has given a notice of petroleum localities in Pegu, and further discussion of the relations of the 'axial' group in Western Prome, while, in addition to these more local and limited notices, a general sketch of the geology of Orissa, and another of the geology of the Bombay Presidency, were also published—both drawn up by Mr. Blanford. This brief enumeration of the principal contents of the numbers will show how much has been done to elucidate the geological structure of the parts of India and adjoining countries in which the officers of the Survey have been engaged.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY two volumes have appeared. It was stated in last report that these were well advanced. Both Vol. VIII and Vol. IX have been issued during the year just closed. In the first of these, Vol. VIII, in addition to brief accounts of three small, isolated, and unimportant coal-fields in Bengal, a long and detailed account is given of an immense area, nearly as large as England, to the north of Madras town, including the districts of Kurnool and Kuddapah, with maps and illustrations. Vol. IX includes a notice of the Peninsula of Kutch (Kach'h), a description of the geology of the vicinity of Nagpúr, a notice of the geology of Sirban hill near Abbottabád in Punjab, and a brief notice of the occurrence of Ammonites in beds, in the Salt-range, containing other fossils universally admitted hitherto as of carboniferous age. This last is one of the most striking discoveries which has marked the progress of Palæontology for many years. The occurrence of the Brachiopoda, *Athyris subtilita, A. Roissyi; Producta costata, P. longispina, P. Humboldtii*, in the same beds would at once be admitted as abundant evidence that those beds belonged to the true carboniferous group of Europe, but with them also occur *Strophalosia Morrisiana*, which would rather indicate a Permian age. There is, however, no question whatever that the association of fossils points conclusively to a Palæozoic epoch, whatever doubts there may be as to the exact horizon in the palæozoic series to which the beds may belong. Now, the occurrence of a true Ammonite in any of the palæozoic rocks is a fact altogether new to stratigraphical palæontology, and opens up a whole field of investigation of the highest interest. The examination in detail of the beautiful series of fossils obtained from the Salt-range has unfortunately been

interrupted by the serious illness of Dr. Waagen, who has been obliged to proceed to Europe on medical certificate, but when completed, this collection will exhibit other novelties besides those already noticed.

Of the PALÆONTOLOGIA INDICA, during the year terminating on 31st December 1872, the portions descriptive of the cretaceous Brachiopoda and of the Ciliopoda have been issued. In the last reports we pointed out the rapid progress which had been made in this series, and showed that the rate of publication was limited chiefly by the amount of funds it was possible to devote to it. The question commended itself to the favorable consideration of the Government of India, and it is with pleasure I acknowledge the liberality which has doubled the sum granted for this valuable series from the commencement of the next financial year. Meanwhile efforts are being made to instruct the necessary artists, lithographers, &c., so as to be ready to take advantage of this. We had, during 1871, issued, as then stated, the portions of the work which represented the fasciculi due up to October 1872. The two parts since issued have been large ones, while the Echinodermata are printed off and only await the completion of the plates. There remain, therefore, the corals to complete the issue of all the groups of invertebrata represented in the cretaceous rocks of South India. These parts combined will form the fourth large volume of the Cretaceous fauna, and will complete the monograph of this very important group. It will form a monument of skill and labour reflecting the very highest credit on the Palæontologist of the Survey, Dr. Stoliczka, and will prove a very fitting description of one of the richest and most varied faunæ ever obtained from a limited area in a limited formation.

A fasciculus of the Cephalopoda of Kutch is ready for issue. This contains all the *Belemnites* and *Nautilidæ*. It was hoped that we should have been able to continue this series without interruption, the succeeding portion being very well advanced; but the illness of Dr. Waagen already alluded to has disappointed this expectation. The series of the Cephalopoda is very extensive, and will prove a contribution to the fossil history of the upper jurassic rocks of the very highest importance and value.

In addition to the regular issue of the *Palæontologia Indica*, some of the more remarkable forms met with in the Salt-range, as already noticed, have been figured in the Memoirs of the Survey.

MAPS.—Some of the sheets of the district of Dumoh, which had been taken up first for publication on the larger scale of our field maps, or 1 inch equal to 1 mile, are ready, and have been kept back until the whole district be completed, which will be very shortly now.

Of the 'Atlas of India' maps, which are to be used as the final record of our work, six quarter sheets were ready for issue to the public at the close of the year. Of these, the four quarter sheets of sheet 79, containing the larger portion of the Cretaceous area of Madras Presidency, were prepared some time since, but had not been issued, awaiting the completion of the adjoining parts. Two quarter sheets, north-east and south-east, of sheet 78 were printed during the year, and the parts of sheet 77 are now in the hands of the engravers. A small map is annexed showing the present state of the publication and preparation for publication of these final maps. These are now printed in colors with much success at the Surveyor General's Lithographic Office, and the general system having been established after several trials, the rate of issue can now be maintained with some regularity.

LIBRARY.—During the year, seven hundred and ninety-six volumes or parts of volumes have been added to the library of this department. Of this number 489 have been presented and 307 have been purchased. As usual, a list of Societies or Institutions from whom

we have received such presentations or exchanges is annexed, while each successive number of the RECORDS has given a list of the additions received during the preceding three months. I rejoice to think that this department has been relieved from the injury resulting to its library from the restrictions imposed on the mode of procuring books, and from the delays consequent thereon. And I doubt not the coming year will again show a return to the larger number of volumes which we have been for years past in the habit of recording. Advantage has been taken of the past year to bring up the binding and securing of our valuable series so far as practicable.

MUSEUM.—The collections in the Museum have been maintained in good order, the additions properly embodied in the general series, and the specimens properly cleaned out and carefully labelled. The collection of minerals, which, as reported last year, had been entirely remodelled and added to so largely, has been in part carefully catalogued by Mr. F. R. Mallet, and it is hoped that this valuable work may be completed during the coming rainy season, when work in the field is impracticable.

The demand for the preparation of a good series illustrative of the mineral wealth of this country to be sent to the great Exhibition in Vienna has entailed on all the officers of the Survey a large amount of trouble and occupation during the last months of the year. The extremely limited and unsuitable accommodation which the present Museum house offered for such extended collections has always prevented our bringing together a collection properly representing the mineral resources of the country. In fact, we had no place to put such a collection if made. While, therefore, our series afforded good specimens in one or two directions, it was necessary to procure fresh and good sized specimens for Vienna. I would here acknowledge the great liberality and very cordial co-operation which I have experienced on the part of the numerous colliery proprietors in the country, who have supplied us with excellent specimens of the coals, ores, tools, &c., from their districts. I am also indebted to the Commissioner of Inland Customs for a very valuable series of specimens illustrative of the salt deposits of India. And in brief, from every one to whom we applied for aid, we have received most ready support. The time at our disposal was far too brief to admit of anything approaching to a complete series being obtained, but that which is to be sent will give a fair representation of the mineral wealth of the country. With the special sanction of the Government, it is proposed also to send some of our unique and valuable collections of fossils, which will excite great interest among the Geologists of Europe, and will afford a much desired opportunity for actual comparison and identification with known European forms.

An Index map is, as usual, appended showing the present state of progress of the field work of the Survey.

The various collections are in as good order and preservation as the limited accommodation at our command will permit.

T. OLDHAM,
Supdt. of Geol. Survey, India,
and Director of Geol. Museum, Calcutta.

CALCUTTA,
February 1873.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1872.

BATAVIA.—Royal Society of Batavia.
BERLIN.—Royal Academy of Science.
DITTO.—Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
CALCUTTA.—Asiatic Society of Bengal.
DITTO.—Agri-Horticultural Society.
CAMBRIDGE, MASS.—Museum of Comparative Zoology.
CHRISTIANIA.—Royal University of Christiania.
COLUMBUS.—Geological Survey of Ohio.
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DITTO.—Royal Asiatic Society of Great Britain and Ireland.
DITTO.—Geological Society.
DITTO.—British Museum.
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MÜNICH.—The Academy.
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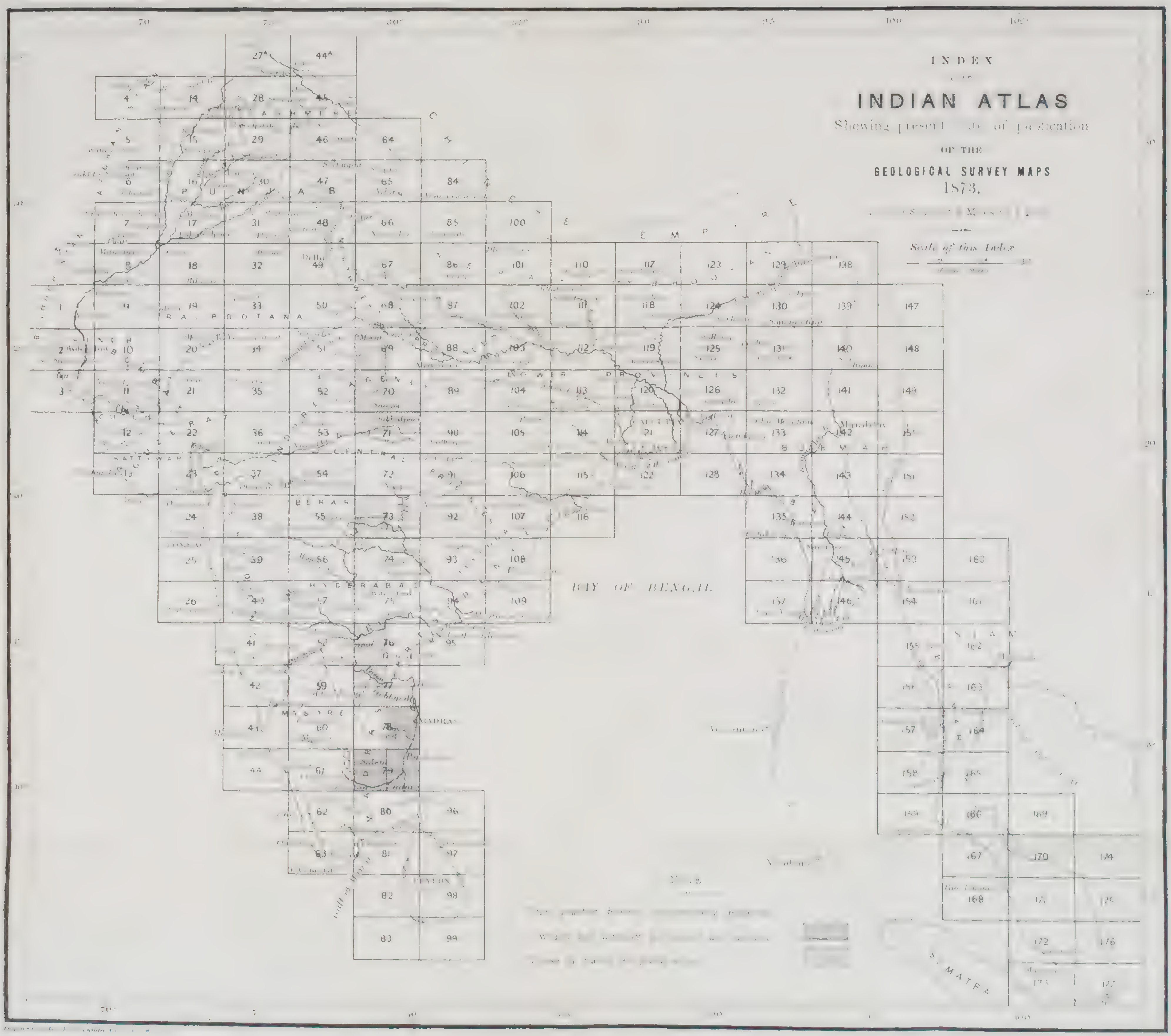
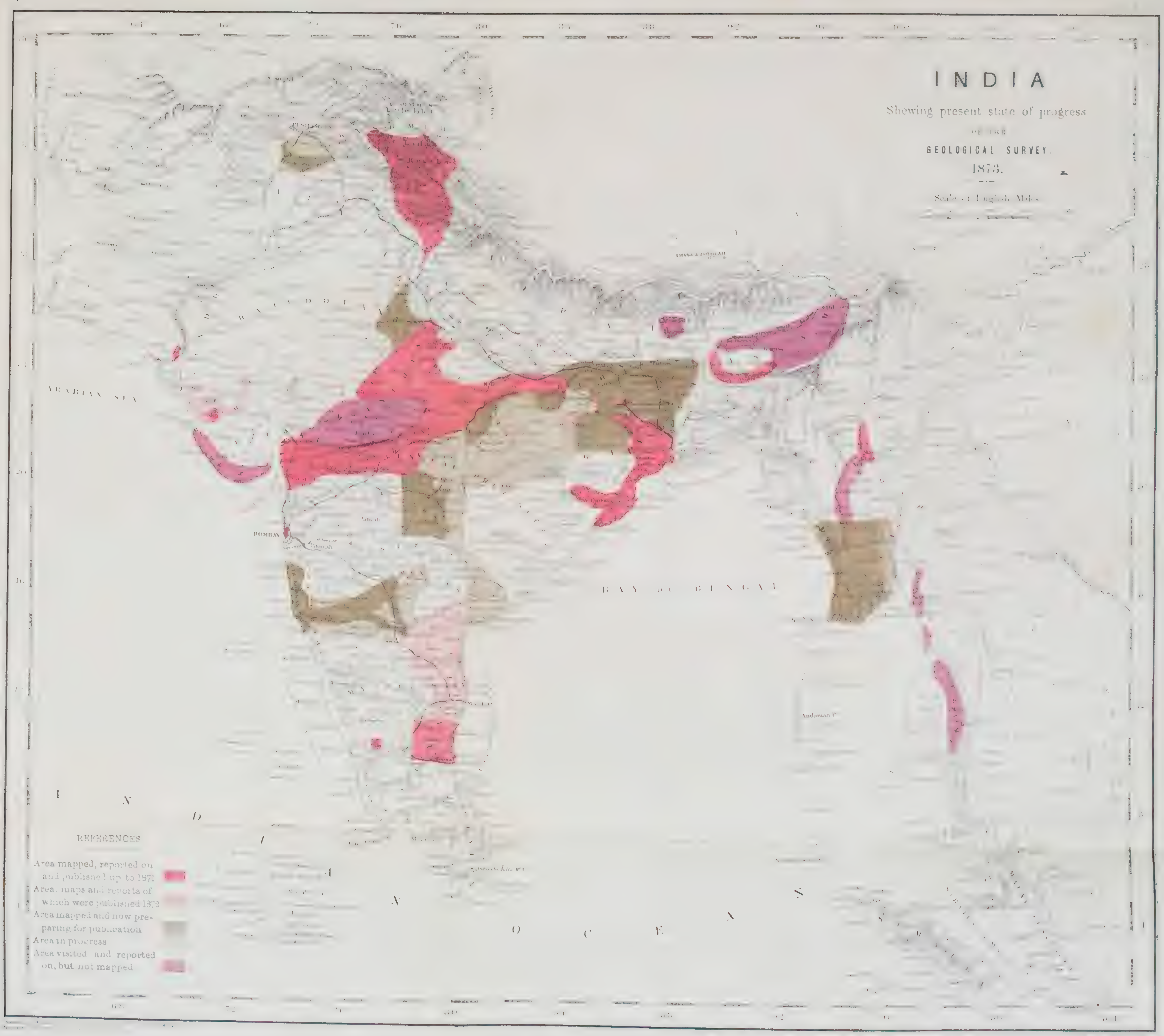
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—L'Administration des Mines.
PHILADELPHIA.—American Philosophical Society.
DITTO.—Franklin Institute.
DITTO.—Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
ROORKEE.—Thomason College.
SALEM.—Essex Institute.
DITTO.—Peabody Academy of Science.
TURIN.—Academy of Turin.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—K. K. Geologische Reichsanstalt.
WASHINGTON.—Smithsonian Institute.
DITTO.—Department of Agriculture of the United States of America.
YORK.—Yorkshire Philosophical Society.

Governments of India, Bengal, North-Western Provinces, Punjab; Chief Commissioners of Mysore, Central Provinces, and British Burmah; Surveyor General, and Superintendent, Great Trigonometrical Survey of India.



Published at the Surveyor General's Office, Calcutta, February 1873.



Published at the Surveyor General's Office, Calcutta, February 187?.

Sketch of the Geology of the North-West Provinces, *by* H. B. Medlicott, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The geology of the North-West Provinces is conveniently separable into three divisions, corresponding to three distinct geographical regions. Twenty-three of the thirty-five revenue-districts are entirely on the Gangetic plains. Three districts on the north—Dehra-Dún, Garhwál, and Kumáon—belong altogether to the Himalayan region. Out of nine districts on the south, seven are in very large proportion covered by the plains-deposits; three only being in whole or in great part within the rock-area of the Peninsula of Hindustan. It is at once apparent that these geographical divisions are also strictly geological; and it may be here stated that no identification has as yet been made out between the rocks within these provinces on the north and on the south of the plains. The formations of these several regions may be noticed in the following order :—

I.—*The Plains.*—Terms applicable to these deposits. Bhángar and Khádar lands. Whether the great rivers are raising or lowering their Khádars. Bhábar and Tarai land. Age of the Bhángar land. Kalar lands.

II.—*The Himalayan region.*—Physical and geological divisions. The Sub-Himalayan series: Sabáthu group; Náhan group; Siválik group. The limestone and slate series: The Krol, Infra-Krol, Blini, and Infra-Blini groups. The metamorphic series.

III.—*The Peninsular region.*—The coal-bearing series: Barakár and Talchír groups. The Vindhyan series: its characters: its distribution. The slate series. The schist and gneiss series.

I.—The Plains.

Terms applicable to these deposits.—The middle region naturally claims first attention It is often spoken of as 'the alluvial plains of the Ganges,' or by such like expressions. In a general sense these terms are admissible: there is no doubt that the materials forming the plains were contributed by the Ganges and by its tributaries. But in this range of meaning the Siválik deposits might claim to be included; for it has been shown that their materials, too, were conveyed through the existing Himalayan drainage system. On the other hand, by confining the word 'alluvium' to its strict geological meaning—to ground subject to flooding from the very channels that now exist—the alluvial ground of the North-West Provinces becomes comparatively small. It is necessary to specify still further to bring out the distinction to be made in the area under notice: the word 'alluvium' is scarcely understood unless as applied to fine deposits from tranquil inundation; and it applies to such indiscriminately; whereas from the proper geological point of view, the distinction to be indicated is what ground is undergoing increase from whatever form of deposition, and, on what ground abrasion (denudation) is in permanent action; or, in other words, where river-action is formative and where it is destructive.

Bhángar and Khádar lands.—A large proportion of the plains-area in these provinces is permanently undergoing denudation. The main rivers run through it in confined and fixed valleys, the flood-level of the waters being well below the general level of the country. Several considerable streams, as the Hindan, take their rise within this area; and though subject to local overflow, with deposition of alluvium, they must, on the whole, carry away annually a large quantity of earth. The fixed valleys of the great rivers are of very variable width, generally bounded by steep high banks; they are called *Khádar*, the adjoining high land being known as *Bhángar*. The deep, low-water, channel of the river oscillates within the *Khádar*, or river-plain; the whole of this being liable to inundation from

the floods, and to constant erosion and re-formation by the action of the current. *Khádar-mati* is very nearly the native equivalent for 'alluvial land.' But though there is always a large total area of true alluvial land in the *Khádars* of the great rivers, it is possible that, on the whole, these *Khádars* are undergoing denudation, that the river-bed is deepening, and that the new alluvial land formed by its changes of position may be progressively lower than the older patches removed by the same process. It has not yet been defined how much, or if any portion, of the eastern districts come within the sub-deltaic conditions that prevail in the Lower Provinces, where the river-action is broadly formative. The whole of the province of Oude would come under one or other of these descriptive terms—*Bhángar* or *Khádar* land.

Whether the great rivers are raising or lowering their Khádars.—The question whether the great rivers have at present a tendency to deepen or to raise their channels is one of much importance in relation to engineering works, and of great interest to the geologist. Within deltaic regions, where the rivers are essentially formative, the process is sufficiently understood: the bed and banks of the main channel are raised, till the contrast of level determines a gradual set of the water to lower ground through some minor distributary; the new channel is at first scoured out to the capacity of the main channel, when the raising action recommences. Within the narrow river-plain of the *Khádar*, there might be no general feature to betray which process is in force. The river would oscillate pretty much alike in either case, removing and replacing the patches of alluvial land. Still it seems likely that careful enquiry among the natives cultivating the *Khádars* would elicit some grounds for judgment: as, if any very old patches of alluvium were no longer inundated by the highest flood, one might infer that the river had lowered its channel. The *á priori* conditions may be stated briefly thus: Whether a river is cutting or depositing depends, of course, upon its velocity and upon the charge of solid matter, wholly or partially suspended in it. As regards the first condition, it can be broadly stated that the slope (and hence the velocity) within the *Khádars* is everywhere much above that at which silt-carrying rivers become on a large scale depositing rivers: at Kánhpúr the fall is nineteen inches per mile, at Alláhábád thirteen; while in the sub-deltaic region at Pátna and Rájmáhál it is only six inches; and in the Delta proper it lowers to three inches.* It is moreover certain that for eight or nine months of the year, the great rivers rush from their gorges in the mountains as torrents of clear water, or only, in the hot months, discoloured by fine glacial mud; immediately upon entering the *Khádar*, however, the water becomes more or less charged with silt and continues so throughout its course. For these months then the river must be denuding its channel. During the flood season, on the contrary, the water issuing from the mountains is highly charged with detritus; which is, to some extent at least, gradually deposited as the slope of the channel becomes lowered in the *Khádar*. It would be difficult to conjecture to what distances within the plains coarse shingle and gravel might be rolled along by the scour of the current in extreme floods during successive seasons. Large stones not being found in the bed of the river in the dry season may not be a safe indication of the case; as it is conceivable that they should always be buried under lighter deposits as the flood subsided. Whether or not the rivers are able, even with the assistance of the clear water for eight months of the year, to carry out of the *Khádar* all that they carry into it in the flood season, cannot be determined without careful observation; but from all the considerations mentioned, it would seem likely that throughout the greater part of the *Khádar* the balance is in favor of erosion. Any tendency of the Ganges and Jamna to lower or to raise their bed at the mouth of their gorges ought to be discoverable from the effect on the canal-heads at Hardwár and Fyzábád.

* These figures are quoted from Mr. Fergusson's paper in the Quart. Jour. Geol. Soc., Lond., Vol. XIX, 1863.

Continued observations on the silt in the water, uniformly conducted at distant places, as at Fatehgarh, Kanhpúr, and Allâhâbád, might indicate whether erosion or deposition is taking place within the Khádar region. But the most satisfactory test would be, continued registration of the rise and fall of the water on permanently fixed gauges, to be checked by an annual exact measurement of the low-water river-section at each gauge.

Bhábar and Tarai land.—Independently of such tracts on the eastern borders of the province as come within the sub-deltaic region of the great rivers, there is a considerable stretch of country where the drainage is formative. The minor streams from the outer skirts of the mountains do not run on into the plains in deep channels cut through deposits of earlier times; they flow, at least for many miles, in broad shallow and ever-shifting beds formed of materials brought down by themselves. The load of shingle, gravel, sand, and earth washed into these torrents by the heavy rainfall from the precipitous slopes of the Siválik hills, formed of soft conglomerates, sandstones, and clays, is far more than the current can carry into the main rivers. It is possible, too, as has just been discussed, that something of the same kind takes place in the upper reaches of these rivers themselves. There is thus, along the northern margin of the plains, a broad belt of ground the formation of which is strictly 'recent.' The portion of it next the hills, having a steeper slope than the rest, is chiefly composed of shingle and gravel with a filling in of sand and earth. This is the forest-bearing zone known as the *bhábar*. Except in the rainy season, it is devoid of water; streams of considerable volume soon sinking into the porous ground, to reappear (at least in part) along the lower fringe of the coarse deposits. This second zone, though having, on the whole, a considerable slope, greater than the general slope of the plains, is thus made watery and swampy; it is well known as the *tarai*. West of the Ganges this formative process is specially active owing to the greater development here of the soft Upper Siválik rocks, which are the most abundant source of detritus. Some years ago, excavations in connection with the Eastern Jamna Canal brought to light the ruins of an ancient town. The tarai in the Jamna-Ganges *Doab* is scarcely a noticeable feature, owing probably to the good natural drainage; the watershed being here 400 feet above the Ganges at Hardwár. Eastwards from the Ganges the *tarai* becomes more and more distinct. In the same direction remnants of an ancient *bhábar* deposit become frequent and of increasing elevation, till in the far east, at the base of the Sikim Himalaya, they stand at 1,000 feet over the actual torrents. To the south of the plains some analogous cases of recent deposits may be found, but they are altogether insignificant; the larger rivers there also running in channels which they do not overflow to any extent.

The phenomena under notice have been only incidentally examined, so that the sketch here given is very incomplete and open to correction.

Age of the bhángar land.—It having been shown that the great mass of the plains-deposits belongs to a bygone period of formation, it devolves upon the geologist to ascertain the age and nature of the process. Very little progress has as yet been made to that end; the systematic study of the question not having been taken up. Some have maintained that the deposits are marine or estuarine; others, as seems most likely, that they are, at least to any observed depth, purely fluviatile, by a process like what is now going on in the Bengal Provinces. No trace of marine organisms has been found in them. But some bones of terrestrial mammalia were got in a hard bed of calcareous gravel in the bed of the Jamna near Etáwá; and which seem to belong to species or varieties now extinct; so that those deposits will probably take rank among the later Tertiaries. From observations made in sinking wells along the line of railway, one of the engineers has stated the general section of the Ganges-Jamna Doab south of Aligarh to be—loam 35 feet, blue silt 30 feet, strong lay 20 feet, resting on a water-bed of reddish sand, from which the water rises some 30 feet.

The bed of clay slopes from north to south at about two feet in the mile, the surface sloping about eighteen inches in the mile. The water obtained from the blue silt is always more or less saline. The only deep section of the plains-deposits is from the boring for an artesian well at Ambála. This position, a little to the west of the Ganges-Indus watershed, is on the zone of recent deposits; the river channels are all superficial, and become lost in the desert country to the south. There is nothing in the section of the boring to mark a change from these surface deposits to others of an older period. None could, indeed, have been expected, as it is only on an extended horizontal section that a plain of denudation, such as that of the present Ganges-Jamna Doab, could be detected between any older beds and perfectly similar materials recently overlaid upon them. There is moreover no presumption that any such break exists in the plains-deposits west of the main watershed, or at least at that watershed. A single boring, too, can tell little or nothing of the arrangement of the strata. The depth reached was 455 feet, or 450 feet above the sea-level. Frequent alternations of clay and sand were passed through. At 286 to 296, and 400 to 417 feet, coarse gravel and large stones were found; strong beds of clay occurring again beneath.

Kalar-lands.—The presence of alkaline salts to a very deleterious extent in the sub-surface water, and their appearance as an efflorescence in many parts of the country, has been an object of anxious enquiry in Upper India for many years back; especially as it seems on the increase, and most so in connection with irrigation. The efflorescence consists principally of sulphate, carbonate and chloride of sodium; more rarely nitrate; and occasionally with potassium as base. The crude salt with its earthy admixture is called *Kalar* (Kullur). The cultivators also speak of it as *úsar* and *reh*. But the former word is said properly to mean negatively sterile soil; and *reh* is said to be properly applied to the carbonate of sodium (or natron). Several conjectures have been made as to the origin of the *Kalar*: 1, that it is an aboriginal ingredient of the soil; 2, that it is continually being elaborated from the soil by the action of water; 3, that it is brought up by water from saline deposits at some depth from the surface; 4, that it is very largely and to an indefinite degree due to accumulation by evaporation from lodgement of inundation waters. It is not likely that any of these is the exclusive cause; and it is most important to determine in what degree each of them may operate, with a view to determining the remedy to be applied in each case. The third supposition, which would be the most unfavorable of all, may be set aside. There are some spots on the plains of Upper India, as at Bhartpúr, where deep brine-wells are worked; but the ground near them is not *Kalar*-land; and, on the other hand, throughout the tracts of Kalar-land the water of the deep wells is sweet, holding as little as, or even less saline matter than, the water of the great rivers. It is of course known that the *Kalar* salts are in the main the product of the decomposition of silicious minerals by atmospheric and other surface conditions. But the ingredients of alluvial deposits are entirely made up of mineral detritus that has already undergone the principal phase of this soil-producing action; and its further decomposition would be very slow indeed. Whatever opinion may be maintained regarding very ancient *Kalar*-land, all the evidence upon the recent formation of these salts goes to prove that it is due to accumulation by evaporation in water-logged land; and it is a necessary corollary from this that water-logging from river or canal inundation must immensely increase the rapidity of its growth. Flooding from rain would be limited to the salt-resources of the ground affected, or of such local drainage as it received; whereas river or canal inundation would be an inexhaustible source of importation of these salts. Various remedies have been suggested for this most serious evil: the cultivation of plants, such as the barilla plant, which assimilates a large amount of some of these salts; the application of suitable mineral manures, so as to facilitate the utilization of these salts by ordinary crops; the application of efficient drainage. If one had only a definite amount of Kalar to deal with, as would be the case supposing it to be of purely

local origin, the application of the first two methods might be sufficient. But with an inexhaustible and ever renewed source of the salt, such as is supplied by river and canal water (both being drainage water), it seems evident that efficient drainage is the only sufficient remedy.

II.—The Himalayan region.

Physical and Geological divisions.—In Kumáon and Garhwál the boundary of the Province extends up to the great snowy range, the frontier of Tibet. West of the Ganges, the District of Dehra-Dún (including Jaonsár) comprises only a small portion of the Lower Himalaya. The mountain-area presents three well-marked physical zones. There is a narrow fringe of low hills, which, from their analogy to similar ridges in other countries named after the range to which they are subordinate, have been called the Sub-Himalayan range. North of these the mountains rise abruptly to an elevation of 6,000 to 7,000 feet; and from here there is a broad belt, some fifty miles wide, of ridges having this elevation, or but very little over it, up to the base of the great snowy range. This middle zone has been designated the Lower Himalayan region. The geology of the hills has as yet been only cursorily examined. The rocks that appear within the limits of this province may be noticed under three heads: 1st, the Sub-Himalayan series, corresponding in distribution, at least in its upper groups, with the lower hills designated by that name; 2nd, a limestone and slate series, occurring very constantly in a belt of varying width along the margin of the Lower Himalayas, as at Naini Tál; and 3rd, a metamorphic series with granitic protrusions, forming the rest of the Lower Himalayan region, and also the line of snowy peaks; close upon the northern flanks of which, beyond the frontier, there rest the Palæozoic and Secondary rocks of Tibet.

The Sub-Himalayan Series.—The youngest of these divisions, the Sub-Himalayan series, includes a wide range of the Tertiary period; from the nummulitics up to the Miocene Sivaliks; and these are closely connected with the Pliocene deposits of the plains. In this series three well marked physical stages have been described. In point of elevation the order of sequence of these has been reversed—the oldest being highest and the youngest lowest, in their respective zones. This has not taken place by inversion; nor yet (it has been argued) by upheaval in steps, through faulting. Appearances are best explained by the supposition, that during successive periods of elevation an irregular scarped line of erosion was weathered out along the newly raised strata (like the present cliffed face of the Sivalik hills); and that against this, as boundary, the newer groups of deposits were accumulated, just as we see the *bhábur* slopes of the present day. As would result from such a process, the oldest group has been most elevated and longest exposed, and so has suffered most from denudation. Only remnants of it are left along the margin and on the flanks of the higher hills.

The Subáthu group.—The typical area in which all the sub-divisions of the lowest group are seen lies out of the North-West Provinces, to west of the Jamna. The hill stations of Kusaoli, Dagshai, and Subáthu are on these rocks, which take their name from the last of these places. The base of the group consists of brown clays with limestones and fine sandstones, passing up into thick red clays and strong sandstones. The age of the lower portion is well characterized by abundant *nummulitic* fossils. Only a very small remnant of these beds has yet been observed in these provinces. It occurs on a gap of the ridge bounding the Eastern Dún, close above Rikikés, and just north of the village of Bone. The hills of Kumáon and Garhwál have been only cursorily examined, and other outliers of this group may yet be found.

The Náhan group.—The middle group of the series is largely developed in the hills immediately at the base of the mountain range, as spurs of which they might be hastily

described; but their distinctness as a range is well marked by a line of low gaps and open longitudinal valleys along the geological boundary, the drainage passing through the range by narrow transverse gorges. These features may be well seen along the Western Dún under Masúri. In the Eastern Dún, from Rajpúr to the Ganges, this flanking range has been removed; but east of the Ganges it appears again in great force, continuing so up to the Nepal frontier. The strata are well exposed along both roads up to Naini Tál. They consist principally of massive gray sandstone (very like the molasse of Switzerland), with subordinate bands of clay. The small nests of lignite found at many places in the sandstone have more than once given rise to exaggerated hopes, and even to confident statements, as to the existence of coal. The fine hæmatite iron-ore of Dechouri near Kálidúngi is only a local concentration of the iron oxide which occurs so freely disseminated as an ingredient of the clays. This middle member of the series has been called the Náhan group, from the chief town of Sirmúr.

The Sivalik group.—The youngest member of the Sub-Himalayan series is the Sivalik group, so called from the name given to the outermost range of hills by Colonel Sir Proby Cautley, who found in those rocks the splendid collection of vertebrate fossils, partially described by Dr. H. Falconer in the Fauna Sivalensis. These hills are much lower than those of the middle group, from which they are generally separated by the broad longitudinal valleys known as the *dúns;* which are structural features, not mere valleys of denudation. The form of disturbance of the strata is very regular: broad 'normal' anticlinal flexures, the axis-plane sloping towards the mountains. The Sivalik hills have been weathered out along the axis of the flexures; and the *dúns* lie on the flat northern slope. The original 'Sivalik Hills' are that well-defined portion of the range between the Ganges and the Jamna separating the Dehra-Dún from the plains. From a short distance east of the Ganges the range is broken and scarcely recognisable, having probably been denuded off and covered up, if indeed it had ever been so prominent as to the west. The *bhábar* deposits here often reach up to the base of the inner range of the middle group of rocks. The Pátli Dún is an irregular valley of denudation in these hills of the Náhan group. The lower part of the Sivalik group is very like the Náhan group in composition, save that the sandstone is softer and fresher. At top there is a great thickness of conglomerate, both earthy and sandy. The physical separation between the Sivalik and the Náhan group has recently been clearly made out; but the distinction was unfortunately not observed in the collection or the description of the great series of fossils formerly procured from this region. The vast majority, if not all, of the large mammalian remains were obtained from the younger group; some vertebrate fossils were found in the Náhan rocks, but they were in great part lost or were mixed with those from the Sivaliks: a very interesting point—the comparison of the two faunas—was thus missed.

The limestone and slate series.—The second rock-system to be noticed consists of an unknown thickness of slates, limestones, and sandstones, forming the first range of the mountains from end to end. The stations of Chakráta, Masúri, and Naini Tál are on those rocks. The strata are greatly contorted, although preserving a strike approximately parallel to the mountain range; and the relations of the several bands of rock can now be only vaguely suggested. From the more regular sections in the hills west of the Jamna the series has been roughly divided, in descending order, into—The Krol limestone; the Infra-Krol slaty shale (often carbonaceous); the Blini limestone and conglomerate; the Infra-Blini slates. It is the Krol limestone that determines the picturesque outline of the outer ranges, as at Naini Tál, compared with that of the great mass of the Lower Himalayan region. The Blini limestone has also been traced eastward, along the outer flanks of the mountains, to as far as under Naini Tál. The Krol group has been asserted to be of triassic age; but the only fossils certainly known to have been procured from these rocks

within these provinces were some indeterminate casts of bivalves from a band of limestone in the gorge of the Tál river, at the east end of the Dehra-Dún. The lead-mines of Sirmúr and those near Subáthu are in this series of rocks. Trappean intrusions occur at many places in them.

The metamorphic series.—At many places, as on the Simla section, there is a complete transition from the slate series into the crystalline schist series, through a graduated metamorphism. Elsewhere the passage is abrupt, as in the valley north of Naini Tál, where the junction is complicated by profuse trappean intrusion. The great mass of the lower Himalayan region, and also of the snowy range, is composed of crystalline schists, gneiss, and granite. There is a large mass of intrusive granite near Almora. Copper ores occur at many places, and are worked by the natives. They have not been favorably reported on by European mineral-viewers. There are also many fine bands of rich iron ore; but the inaccessibility of the ground prevents their being extensively used. Impure graphite is found in several places.

III.—The Peninsular region.

Although the rock-area south of the plains and within the North-Western Provinces is very small, it forms an extended line; and thus it includes representatives of the principal rock-series of Hindustan, excepting only the Deccan trap formation and the cretaceous rocks below it. There are thus to be noticed—

The coal-bearing series.
The Vindhyan series.
The slate series.
The schist and gneiss series.

The coal-bearing series.—The great plant-bearing series of rocks, so widely scattered over India, has been divided in different basins into a number of well-marked groups. But the characters of many of those sub-divisions, or their equivalence in time, do not exactly correspond from one basin to another, so that it is impossible as yet to adopt a scale of groups applicable throughout. The two bottom groups of the series are the most widely distributed and the most constant in character. The Talchírs, the lowest group, is of special interest as exhibiting undoubted glacial action in very ancient rocks (probably Palæozoic), and in what is now an intertropical latitude. The most characteristic bed of this group is a fine greenish-gray silt, in which there frequently occur huge boulders of rock, sometimes rounded, and sometimes, in the same spot, quite angular, occasionally polished and deeply grooved by friction; just as is at present only known to occur in glacial deposits. It is not possible at present to conjecture to what conditions—whether to great elevation, or to change of climate from cosmical causes—these phenomena were due. In most of the fields throughout India the coal-measures are confined to the Barakár group, which is largely made up of coarse felspathic sandstones.

In British Singrowli, the southern extremity of the Mirzapúr District, there are about forty square miles of the Talchír group exposed; and about twenty more overlaid by the Barakárs. From the Kota mine in Singrowli all the coal was procured, which used in old times to be carried on pack-bullocks for forty miles, across the Vindhyan plateau, to Mirzapúr, for the steamers on the Ganges. The sandstone forming the small plateau over the coal-measures at Kota probably belongs to one of the upper groups of the series. This is the only patch of this series of rocks within the North-Western Provinces. It is the eastern extremity of the great central basin of South Ríwah.

The Vindhyan series: its characters.—The base of the plant-bearing series is separated all over India by total unconformity, involving a great break in time, from the next preceding formation, which is known as the Vindhyan series. The precise range of this series has

not yet been fixed. The rocks to which the name was first given, or rather adopted from the old geographical name, are the strong fine sandstones forming a very long range of cliffs along the north side of the Narbadá valley from Hosungabad to Jabalpúr, and continuous thence along the north of the Sôn valley to Sasseram in Behar. As the sandstones recede from this line of cliffs, they become steadily split up by thick bands of shales, with limestones, and so necessitating a division into three principal groups, as Bhanrer, Ríwah, and Kaimur, forming the original Vindhyan series. In the Sôn valley the sandstone cliff is weathered back to the north of its line in the Narbadá country; thus exposing older beds, underlying the Kaimur sandstone. These consist of limestones, fine flaggy sandstones and shales, with strong bands of very peculiar porcellanic and trappoid beds; the whole forming a series of local groups. Beds of exactly the same description as those of the Són Valley appear again along the north edge of the Vindhyan basin; and here also they stop out against the gneissic rocks of lower Bandélkand, and so are entirely overlapped by the Kaimur sandstone. They were here first described as the Semri series, but are now properly merged in the Sôn series. As these strata present throughout steady parallelism with the Vindhyan beds above them, both occupying the same basin, being alike affected by local disturbance, and alike free from any symptoms of metamorphism (except the conversion of the sandstone into quartzite in certain positions of disturbance), the name Vindhyan has been extended to the whole series, with only the distinction of Upper for all the original Vindhyans and of Lower for the Sôn series. On the north side of the gneissic area of lower Bandelkand, about Gwalior, there is a group of rocks resting, just as the upper Vindhyans themselves do, upon an old surface of the gneiss; they have scarcely undergone any more disturbance or metamorphism than the Vindhyans; but the Kaimur conglomerate rests unconformably upon an ancient surface of erosion of these rocks, and is largely made up of their débris. There is, however, at least one marked character common to the Gwaliors and the lower Vindhyans—the peculiar porcellanic and porphyritoid beds occur in both; and it would be by no means improbable to suppose that the two are in part cotemporaneous deposits. There are also marked differences between them; the Gwaliors are highly ferruginous and include some strong sheets of cotemporaneous basic trap. These new characters, on the other hand, suggest another link in the descending series of formations: recrossing the same gneiss, to the south, we find in the Bijáwar country a new group of rocks, still again resting flatly upon an eroded surface of the gneiss, only partially disturbed and showing only incipient metamorphism, but upon which the original lower Vindhyans rest unconformably. Cotemporaneous trap and highly ferruginous deposits are marked features of this Bijawar group; and it would not be extravagant to assume that it is, in part, cotemporaneous with the Gwalior group. Again, in the Són Valley, the lower Vindhyans rest with extreme unconformity upon beds that have been thought to represent those of Bijáwar, and which have become highly metamorphic and associated with gneissic rocks. We thus finally arrive at the suggestion of a younger and an older gneissic series; without finding, below the Vindhyans proper, a clearly marked physical break applicable generally over even so small a geological field as the Indian Peninsula.

The stratigraphical difficulties observed in the preceding paragraph might be removed by the aid of fossils; but to the great disappointment of geologists in India, the Vindhyans have as yet yielded no organic remains, although the undisturbed and unaltered strata composing them, often covered with fine ripple marking, continually tempt one with the hope of successful search. Some forms supposed to be corals were found by Mr. Hacket in a limestone of the Gwalior series.

Besides producing in abundance building stone of first rate quality and limestone, the Vindhyans are only remarkable as containing diamonds. The mines near Pannáh are

now more worked than any others in India. The gem is, of course, found in the diluvial deposits; but the diggings most prized are in the Riwah group of the Vindhyan series. Although, however, this group has a very wide range, diamonds are not known to occur in it beyond a very limited tract in the State of Pannah. This fact and other observations have suggested that the diamond was not originally formed in the Riwah group; but rather in some peculiar contact-rocks at the base of the lower Vindhyan, or Sôn, series, and well exposed in the sections close to the north of Pannah.

Its distribution.—The Karamnásá, forming the eastern boundary of the North-Western Provinces, flows from the eastern extremity of the Vindhyan plateau. From here to Futehpúr Sikri (which stands upon a ridge of Bhanrer sandstone), south of Agra, the north scarp of the Vindhyans corresponds approximately with the south boundary of the provinces; the native states of lower Bandelkund being intricately interwoven with the districts of Banda, Lalatpúr, and Jhansi. Only, on the east, the Mirzapúr district stretches southward across the Vindhyan plateau, here formed of the Kaimur group, and across the Sôn valley, where there is a full section of the lower Vindhyan, or Sôn, series. The northern outcrop of this same series is exposed in the Banda district, about Kirwi. The Gwalior series just touches the border of the province in the Etáwah district.

The slate series.—In discussing the range of the Vindhyan series, the Bijáwar formation was mentioned as showing incipient metamorphic action. It is made up of hornstone-breccias, quartzite-sandstone, cherty limestones, ferruginous sub-schistose slaty shales, and thick sheets of basic trap-rock. The districts of Banda and Lalatpúr just touch upon the original area of these rocks in Bijáwar. In the Mirzapúr district, in the hills south of the Sôn, similar rocks occur, in a state of high contortion, and connected on the south with a broad band of clay-slates, which are in turn intimately associated with crystalline schists and gneiss.

The schist and gneiss series.—The wide bay formed by the Vindhyan scarp between Gwalior on the north-west and Kirwi on the south-east is occupied by highly metamorphic rocks,—coarse porphyritoid gneiss and crystalline schists. In the districts of Jhansi and Lalatpúr these rocks appear freely; but to the north-east, in the districts of Jaloun, Hamirpúr, and Banda, outcrops become more and more scarce as the rock disappears under the plains deposits. The strike of the foliation and of the bedding, where observable, is generally east and west. Greenstone dykes are very abundant, with a prevailing north-west-south-east direction. None of these dykes pass into any of the overlying sedimentary rocks, and are therefore presumably of older date. The most striking feature of this area is the prevalence of great quartz-reefs, standing up in great wall-like ridges, sometimes more than three hundred feet high, many yards wide, and running quite straight for several miles continuously, or with intervals appearing again on the same strike. They have a prevailing north-easterly run, but exceptions are frequent. These also are certainly older than the Bijáwar formation, and also apparently older than the trap dykes. It has been thought that gold should be found in or about these great quartz-reefs; but there is no trace or tradition of its occurrence. According to some theories, this would be accounted for by the extreme antiquity of these reefs and of the enclosing gneiss.

The gneiss at the southern point of the Mirzapúr district in Singrowli belongs to the great metamorphic area of Behar and Bengal. Here also massive porphyritic and granitoid gneiss is the predominant rock, with subordinate bands of hornblende schist. There is a strong band of fine Corundum in it near the village of Pipra. Bands of crystalline dolomite and limestone are also frequent in this gneiss; whereas none whatever has been observed in the gneiss of Bandelkund.

H. B. MEDLICOTT.

September 1872.

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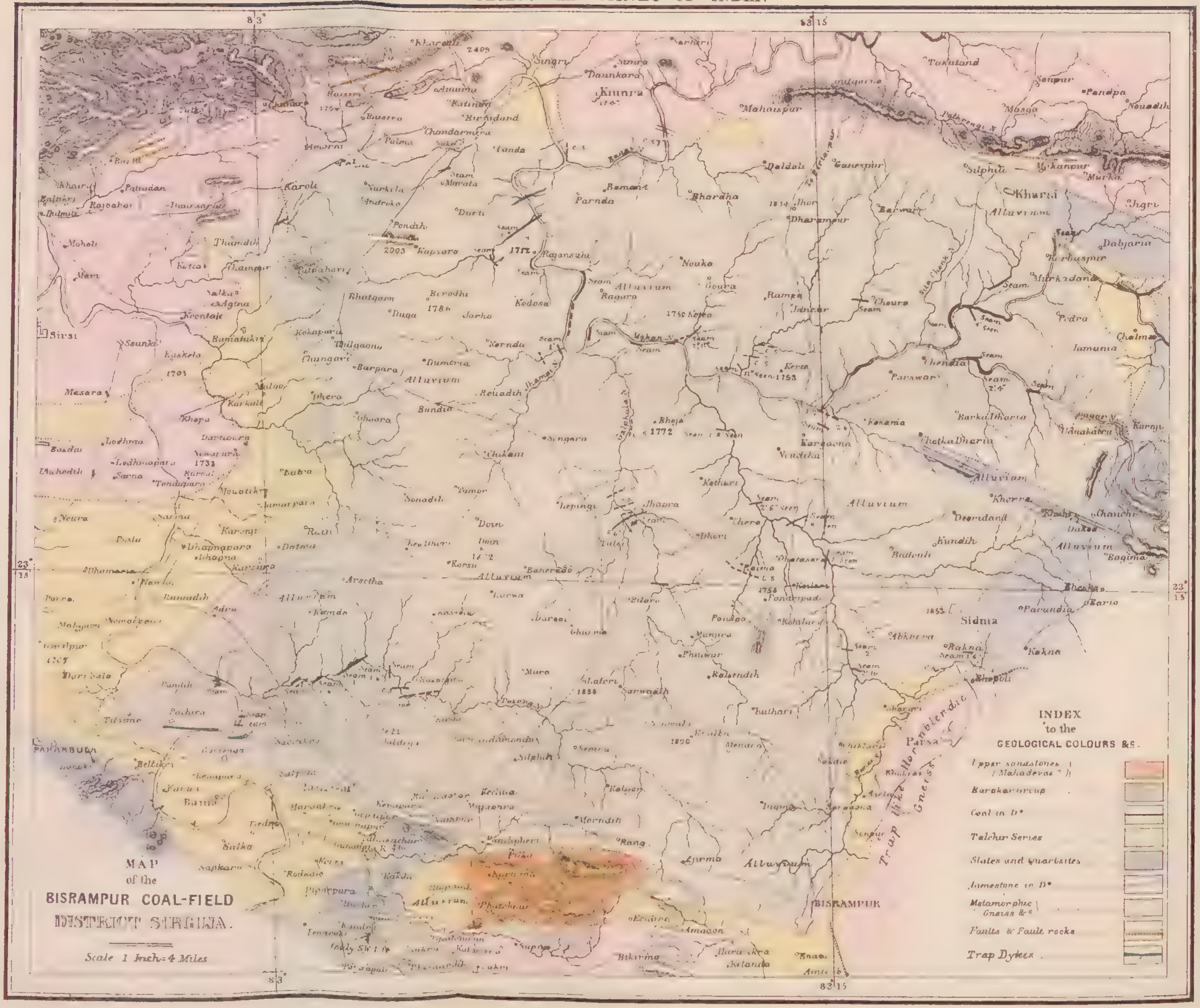
January 10th, 1872.


MAP
of the
BISRAMPUR COAL-FIELD
DISTRICT SIRGUJA.
Scale 1 Inch = 4 Miles
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Barakar group
Coal in D°
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Slates and Quartzites
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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1873. [May.

THE BISRÁMPÚR COAL-FIELD, *by* V. BALL, M. A., *Geological Survey of India.*

Name.

Position and boundaries.

The above name being that of the capital town has been given to an area of coal-measure rocks which is situated in the eastern portion of the comparatively low-lying ground of Central Sirgújá. On the north and east the limits of the original basin of deposit are defined by, in the former case, a ridge of low hills composed of metamorphic rocks, and in the latter by the flanks of a plateau formed of the same rocks. This plateau rises from 1,000 to 1,800 feet above the generally elevated country of Western Chota Nágpúr; thus forming a step or barrier between Lohardugga and Central Sirgújá.

In some cases the ancient valleys and indentations in these bounding walls of the basin are occupied by prolongations from the rocks of the Tálchír formation, which, as they crop out on all sides, probably underlie the coal measures throughout. Instances occur, notably one, where spurs from the metamorphics penetrate into the area now occupied by the coal measures. With these exceptions the latter lie within well defined boundaries, which, to a comparatively small extent only, have been affected by faults. On the south and west the case is very different. The original boundaries of the coal measures are far removed from the present limits; and broken and semi-detached extensions of the sedimentary rocks, especially the Tálchírs, connect the Bisrámpúr field with other coal-fields, which, however, for all practical purposes are, and for purposes of description may be, most conveniently regarded as distinct.

Area.

The coal measures whose limits have been thus defined occupy an area of about 400 square miles, throughout which, except in the river beds or their immediate neighbourhood and on a few small hills, no rocks are exposed: a considerable covering of alluvium concealing all. To such an extent is this the case that a traveller might pass over the Bisrámpúr and Partábpúr road for twenty-two miles without seeing a single outcrop of Barákars, save at two or three of the river crossings.

Drainage.

The level of this area falls gradually from south to north, Bisrámpúr at the south-east corner being 1,943 and Kiunrá on the northern boundary 1,747 feet above the sea level.

The drainage of the eastern three-fourths of the field is effected by the Máhán river and its tributaries. The waters of the remainder are carried directly into the Rehr by the Pasáng and other smaller tributaries. The Máhán itself joins the Rehr at a point a few miles to the north-west of the field, in its course traversing a channel deeply cut in the above mentioned barrier of metamorphic rocks which bounds the field on the north. This fact, if others were wanting, affords evidence of the immense denudation which has taken place. But in the isolated Pilká hill, formed of the upper sandstones which rest on the southern boundary of the field, there is a remnant

Denudation.

of the rocks, which, with a covering of trap, filled up the basins and valleys existing in the ancient metamorphic area. Thus, we can see what were the conditions which gave the river a fall from above, sufficient to enable it in the long lapse of time to cut down through what, under other circumstances, would have been an insurmountable obstacle to the formation of a drainage outlet for this area on the north.

Under somewhat similar conditions, two other considerable rivers, the Kunhur and Rehr, have cut gorges for themselves, through which they are gradually removing away all traces of those rocks whose former presence enabled them to force their way to the Sone.

Thus the valleys and basins are being sculptured and cleared out anew, the sedimentary rocks broken up into detached areas, and the basal metamorphics gradually re-exposed to the direct action of denudation.

Previous observers.

Previous to the first visit of the Geological Survey, the information regarding the existence of coal measures in Sirgújá was of a somewhat hazy character, being chiefly confined to brief notices by the district officers, who in their tours had seen or heard of the existence of coal seams.

Colonel Ouseley, J. A. S. B., XVII, 1848, p. 65.

In a paper on the antiquities of Sirgújá, Colonel Ouseley mentions the occurrence of coal, iron, gold, ochre, marble and lime in that district.

Greenough, Brit. Ass. Report for 1854, and map.

In Mr. Greenough's map the Damúda valley coal measures are connected with those of Sirgújá and the Hutso valley. The incorrectness of this was pointed out in the Report of the Committee on Mr. Greenough's map, appointed by the Asiatic Society in 1866. *Vide* J. A. S. B., XXV, p. 425.

Colonel Haughton, J. A. S. B., 1854, p. 105.

Colonel Haughton states "the Gangpúr coal formation is probably connected with that of Sirgújá and Palamow; but on this point I have no reliable data."

Colonel Dalton, J. A. S. B., XXXIV, pt. II, No. 1, 1865.

Colonel Dalton alludes to the occurrence of coal in parts of Sirgújá.

Topographical Survey Maps, 1867-68.

Localities for coal are given on the 1-inch maps constructed under the superintendence of Major Depree and Captain Sale. Reference will be made to these localities in the following pages.

I.—General Geology.

The sedimentary rocks of this area are referable to three formations, *viz.* :—

Tálchír series.

Damúdá series (Barákar group).

Upper sandstones (= Máhádevás?)

Tálchírs.

As to the maximum thickness of the Tálchírs, there are no sections sufficiently definite to enable us to determine its amount with certainty; but in no part of the field where the rocks of this formation are exposed do they reach 200 feet. In the clearest section in the area—in the Goinghatta—the same beds roll over and over and it is impossible to measure them. Outside what we have adopted as the limits of the present description, there may be a much greater thickness, and in one section underneath the Máin pât, they certainly do exceed 200 feet.

Barákars.

Similarly with the Barákars, though occupying a considerable area, there is no tilting or disturbance of the beds for any continuous distance, the consequence being that no measurements can be made which are of the least value for determining the thickness. The prevalence of sandstones to the almost

total exclusion of the other rocks which go to make up the Barákar group in the eastern coal-fields renders it impossible to identify individual beds in sections at any distance from one another. And the coal seams are far too irregular and variable in thickness to be of much use for this purpose.

From the general horizontality of the beds, from the character of the basin in which they lie, and the outcropping of the Tálchírs on all sides, it is evident that, as compared with the eastern fields, the thickness must be inconsiderable, and I find it difficult to bring myself to believe that it anywhere amounts to even as much as 500 feet.

Upper sandstones.

With the upper sandstones it is less difficult to assign a definite thickness, though it be a minimum one. The horizontal beds which form the Pilká hill are about 1,000 feet thick.

II.—Tálchírs.

Extent of Tálchírs.

The natural geological boundaries of the Bisrámpúr coal measures include an area sufficiently limited and compact for convenient description; but such is not the case with respect to the underlying Tálchírs. Were the usual practice—one very well suited to the Tálchírs underlying the coal measures of the eastern basins—of following out the rocks to their extremest limits adopted in Western Chotá Nágpúr, we should find ourselves obliged to follow the extension in one direction towards Riwá and Mirzápúr, and in the opposite some 100 miles or so towards Sambalpúr.

As it has been found with the metamorphic rocks elsewhere, so the Tálchírs, which spread over such an enormous area in Sirgújá, can be most satisfactorily discussed in a general account of the district, apart from their relations to any particular basin occupied by coal measures.

In describing the distinct areas of coal measures which occur in Western Chotá Nágpúr, I propose in future to adopt artificial boundaries, which will include a limited margin of the surrounding rocks.

Limits of Tálchírs here described.

In the present instance the Rehr river serves as a very convenient boundary, except for a short distance near Pahárbullá, where the coal measures themselves cross it.

Tálchírs west of Kíunrá.

On the north of the field, outside the fault which bounds the coal measures, there are two patches of Tálchírs. The principal of these situated west of the village of Kíunrá, is of an irregular triangular shape, and is traversed by the Máhán river. The rocks in the lower portion of this area adjoining the fault are pebble and boulder beds, with some hard sandstone: the latter I did not at first recognise as belonging to the Tálchír formation, but further on it is seen to pass into true Tálchírs, which extend up the Súkáiá river for about a mile. A short distance north-east of Sugri these rocks are cut off by a ridge of slaty quartzites. In the upper reaches of the stream just mentioned, outside our limits, there is a strip of Tálchírs the boundaries of which have not yet been mapped.

Tálchírs south of Maháispúr.

The second patch of Tálchírs lies south of the village of Maháispúr; it is of quadrangular shape, and is in area about $1\frac{1}{4}$ square miles. Its northern boundary is very irregular, a stream which runs with it alternately exposes Tálchírs and metamorphics.

From the position of the faulted boundary, which is well seen in the Bánkí river close by, there can be little doubt that these patches lie outside the run of the fault, but I did not succeed in finding any point where the section showed direct opposition of the edges of the Barákars and Tálchírs.

From the eastern corner of the field, a long irregular strip of Tálchírs runs with the valley of the Máhán towards Uphiá, near which place it probably disappears under the sandstones exposed on the southern face of the Máilán pât. So far as it could be traced between Uphiá and Bárbáspúr, it appears to be unbroken for about fourteen miles. When it does not occupy the present bed of the river, it is often much obscured by alluvium and jungle. The boundaries of this strip are frequently indented by noses of metamorphics and submetamorphics, and there are also several inliers of the same rocks.

Tálchírs in Máhán valley.

The bottom rocks of the Tálchírs in the sections exposed in the Máhán are the boulder bed with very irregular bedding and a hard grit sandstone. Overlying these is a considerable bed of yellowish-green sandstone, which, near Bárbáspúr, has been thrown by a cross-fault against the edges of the Barákars. In the Máhán itself shale beds are of comparatively rare occurrence, but they are exposed in some of the sections in the streams which join it on the south.

One point in reference to the boulder bed, which plasters over quartzites and slates in the river south of the Ránchí and Partábpúr road-crossing, is deserving of especial notice, as it has an important bearing on the origin of that rock. The principal proportion of the boulders are derived not from the underlying rocks, but from the granitic gneisses which occur three miles to the north. One rock, a pink porphyritic granite, which is seen *in situ* north of Tárki, seems to have been a prolific source of these boulders.*

Origin of boulders.

A branch from the strip of Tálchírs above described borders the Barákars southward as far as Karnji. This branch is traversed by the Gehúr river, in which there is a section of sandstones and boulder bed, which continues up to the mouth of the Doldoá stream, where slates and quartzites strike into the river and continue in its bed for several miles.

Tálchírs on eastern boundary.

In the Gágur river west of Karnji there is a very intricate section in which Barákars, Tálchírs, Slates, Tálchírs, Slates, and Barákars are successively exposed.

The jungle on the banks is very dense, and the map is, probably from that reason, deficient in detail, so that it is difficult to trace out the geological boundaries. The accompanying map may, however, be taken as affording a fair approximation to the true state of things. The second appearance of the slates is due to the same cross-fault as that above mentioned at Bárbáspúr. They occur as a very small inlier in the base-beds of the Tálchírs, whose ends are against the Barákar sandstones.

As to the continuation of this fault further south, I could see no satisfactory evidence. Possibly it bounds the Tálchírs south-east of Udúkatrá, but with the streams, in which the Tálchírs are exposed, inclining, according to the map, to the westwards, it is impossible so to represent it.

Fault.

Between Kárnji and Chárgar there is a very small patch of Tálchírs exposed in the low ground.

North-east of Sidmá there appears to be a narrow strip of Tálchírs cropping out from underneath the Barákars, but the evidence of its existence is afforded rather by débris in the stream, than from rocks *in situ.*

Tálchírs north-east of Sidmá.

* In some of the boulder beds which occur in the country west of the Rehr, a considerable proportion of the boulders consist of a reddish quartzite sandstone, probably of Vindyan age, which, if that supposition be correct, must have been transported to their present position from the neighbourhood of the Sone. This could only have been effected through the agency of ice.

Near the village of Bhopoli there is seen the commencement of another bordering strip, which is traceable in the bed and neighbourhood of the Bánki river; thence to Bisrámpúr it is covered and obscured by alluvium; but sufficient is seen to enable two branches of Tálchírs to be traced with approximate accuracy, one extending southwards to the Máin pât, where it is covered by the upper sandstones which underlie the trap, and the other westwards to the Pilká hills, under the sandstones forming which it also disappears.

Tálchírs between Bhopoli and Bisrámpúr.

The first of these branches is between seventeen and eighteen miles long, with an average of about three miles in width. On the east the boundary is throughout natural, but the western boundary is in part faulted, with an inconsiderable throw, against the metamorphics.

Eastern branch.

The best section of the rocks in this strip is exposed in the bed of the Goinghátta, between the villages of Pári and Librá, where sandstones, pebble and boulder beds, and needle shales, all of typical appearance and lithological character, are seen.

Section.

In several of the reaches a peculiar effect is produced by the gneiss boulders, which have been washed out of the boulder bed, and are scattered about on the surface, as though they had been only just dropped from floating ice. One boulder, still *in situ* in the bed, gave the following dimensions 7′ 4″ × 6′ 8″ × 2′=97 cubic feet, and I observed several others which could not be measured, which were still larger. Further south in the valley of the Barnái, where the strip is bounded by two ridges of gneiss hills, the boulder bed, shales and sandstones, all occur, but no clear, consecutive section is exposed.

The Tálchírs which stretch westwards from Bisrámpúr to the Pilká hills, are faulted against the metamorphic rocks along the southern boundary. The line of junction between them and the Barákars on the north, is completely hidden by alluvium, but the probabilities are in favor of its also being faulted, as west of the hill its continuation certainly is so.

Western branch.

The Tálchírs disappearing under the grits and sandstones of the Pilká hill, re-appear on the western side much increased in their lateral dimensions; this is due partly to the original divergence of the boundaries, and partly to the effects of a cross-fault, the position of which is marked by a ridge of fault-rock at the south-west corner of the hills, and by the effects produced by it in the Rámpúr coal-measure area, of which more hereafter.

Between the hills and the Rehr an irregularly shaped area of quartzites cuts the Tálchírs in two parts, running up to both boundaries and being faulted against the Barákars. Resting on these quartzites, are three small patches of Tálchírs, remnants of the rocks which at one time spread all over them. An isolated outcrop of these quartzites is exposed in the Goinghátta section, in which, as well as in the Rehr and its tributaries, Tálchírs are seen in many broken and detached sections.

Quartzites.

The further extension of the southern fault, westwards from the point where it crosses the Rehr, is not at present known. The Tálchírs continue to border the coal measures to within a mile and a half of Pahárbullá, where the latter terminate. At Pahárbullá the extension of the Tálchírs in a southerly direction is limited by a considerable group of quartzite and slate hills, which will probably prove to be bounded on the south by the above-mentioned fault, whose western extension has not been yet traced out.

Pahárbullá.

As stated above, the Tálchírs extend far to the west of the Rehr, underlying one or more distinct areas of coal measures. The present account is limited to that portion of them bordering the coal-field and east of the Rehr.

Tálchírs west of Rehr.

Section in the Rehr.

The boundary between the Barákars and Tálchírs is pretty well seen in the Rehr north of the village of Púndih; but in the surrounding country the rocks are completely obscured by alluvium, and I have been compelled to draw the boundary straight from point to point. It is probably somewhat less regular than is represented.

Proceeding northwards from this junction down the bed of the Rehr, there are greenish and yellow sandstones with some shales and flaggy beds, which are chiefly exposed at the salient points in the bed of the river.

Sandstones what?

East of Sármá there are some rather coarse sandstones, not altogether like Tálchírs, but apparently geologically inseparable from other more typical rocks of that series. A short distance beyond, a nose of submetamorphic-looking quartzites and hornblendics strikes into the river. From the mouth of the Jumarpárá stream northwards for about three miles no Tálchírs are seen in the Rehr, the rocks exposed being for the first mile hornblendics and slaty quartzites, with a west-north-west, east-south-east strike, changing to east and west. Nearly due west of Khopá V. S., coarse granites come in and continue up to and beyond Khopá.

The Tálchír boundary leaving the Rehr close to the mouth of the Jumarpárá stream strikes north-eastwards, passing round the village of Nouápárá.

In the streams north and south of Káronji the rocks are much covered; but where exposed, except at one spot below the village, they are clearly Tálchírs. At that point there are some coarse sandstones, which I could not, as in the previous case, satisfactorily separate.

Gobri sections.

In the Gobri river and its various tributaries which traverse the country between Chungári and Datmá the boundaries between the Tálchírs and Barákars are very obscure. This is owing partly to the imperfections of the sections, partly to the presence of rocks of indefinite character, colored like Tálchírs, but lithologically resembling Barákars.

There is an inlier of Barákars south of Dhorá whose boundaries can only be approximately represented. A reference to the map will explain the position better than any description.

North and north-west from Nouápárá the Tálchír and metamorphic boundary runs with the Gobri, where it is very irregular and intricate. The river exposes granitic gneiss and Tálchír rocks alternately. West-north-west of Kurkáli, a belt of Tálchírs, half a mile wide, occupies the low ground below Káskelá, and is seen in contact with the edges of the gneiss under the east bank of the Rehr.

Boundary at Sálká.

Boulder beds.

Leaving the Gobri the boundary bends round Aginá and Sálká. At the latter place there is a remarkably fine boulder bed. The large masses of gneiss which have been washed out of it, when seen from a short distance, look like rock in situ. A mile north of Kotiá the Tálchírs are cut off by the fault which bounds the field.

Outlying patches.

A few small outlying patches of Tálchírs occur in the metamorphic area which intervenes between the north-west corner of the Bisrámpúr field and the eastern extremity of the Jhilmilli coal-measure area.

III.—Dámúdá Series.

Barákar Group.

Rocks in high ground.

Before proceeding to the description of the rocks exposed in the river sections, it will be well to say a few words on the localities where the rocks appear in the high ground uncovered by alluvium. For the most part the rocks so exposed consist of coarse grits, and pebble beds which form bossy mounds or small hills.

Boundary of Barákars marked by vegetation.

A few very striking instances occur, where the hidden boundary of the Barákars is sharply defined either by the character of the jungle growing above, or by the undulating or sloping character of the surface, as compared with that of the ground, where the underlying rocks are Tálchírs or metamorphics.

Grits at Mukánpúr, &c.

At the north-east corner of the field close to Mukánpúr there are some small mounds of a coarse grit, which are separated from the gneiss by a run of fault-rock. In the country to south-west bending to south as far as Chánchi, there is high ground, some of the hills, as the Bál H. S., rising 100 feet above the plain. The rocks are coarse sandstones and grits, with bands of pebbles, which are sometimes of considerable size and little water-worn.

In the neighbourhood of Koilári there are coarse grits near the surface, most of them excessively ferruginous.

At Bárdhá there are mounds of whitish grit sandstones.

Púnri hills of pebbly grit.

Close to Púndih (or Púnri) there are several small hills, the highest of which is 200 feet above the plain. The principal rock forming them is an open-textured grit with pebbles, which I was at first disposed to regard as belonging to the upper group, as it presented the very strongest resemblance to the rocks of the Pilká hill. However, with the general resemblance which exists between the Barákars and rocks of the upper group, it is, in the absence of any well marked geological features, almost impossible to attempt the separation of such isolated patches. South of the hill there is a run of fault-rock, which marks the continuation of the bounding fault of the north-west corner of the field. So far as I could see, its throw must be inconsiderable. I am the more inclined to regard the Púnri rocks as Barákars, in consequence of the range near Bhatgáon, which is at the same level, being formed of rocks exactly similar to the grits and pebble-beds on the east of the field, north of Chánchi. Towards the south and south-west of the field, as at Sidmá, Bisrámpúr, Karwá, and Jáinnagar the coal-measure rocks are completely concealed by alluvium.

Fault.

In describing the river sections, I shall begin with the Máhán, and then take up the tributaries successively from east to west.

Máhán River Section.—The first Barákars exposed in the Máhán section* are seen near the village of Bárbáspúr, where, as already stated on a previous page, they are faulted against Tálchírs. South of the river Barákars occur outside the fault; possibly some of the sandstones seen in the river too, should be so grouped, but at the fault there is a greenish sandstone which is certainly Tálchír.

Seam.

On the west of the fault there is a small seam of carbonaceous shales with irregular coaly layers.

From this down to the mouth of the Dekiá stream the section exposes sandstones with some carbonaceous shales; but even of the latter, at the point west of Bedrá where *coal* is marked on the published map, there is not a trace of shales, much less any sign of coal. Here as well as at several other points to be noticed in due course, the Topographical Survey must have marked *coal* from seeing drifted pieces lying at those points and not seams in situ.

Seam.

Opposite the mouth of the Dekiá stream there is a seam, of which 4 feet, consisting of coal and carbonaceous shale, is exposed. The coal is of inferior quality, but burnable. The base of the seam is quite concealed by sand and water; possibly there may be a better quality of coal below.

* Disregarding for the present the probable occurrence of Barákars in higher reaches of the river outside the limits of the Bisrámpúr coal-field.

Higher in the section there is a considerable seam, which is exposed along the northern bank. The clearest view of it is to be obtained in the next reach.

Seam.

The actual base is concealed, and the top much weathered and covered by surface débris. Section ascending. Dip variable (rolling).

1.	Shales	...	
2.	Coal		5½″
3.	Concretionary shale		8″
4.	Flaky coal	2′	
5.	Concretionary shale		10″
6.	Same as No. 4; portions more coaly; contains much iron, about ...	2′	8″
7.	Concretionary shales	2′	3″
8.	Hard band of strong coal	5′	
9.	Same as No. 6	2′	
10.	Hidden, about	4′	
11.	Concretionary shales		8″
12.	Flaky coaly shale	1′	
13.	Concretionary shale	3′	2″
14.	Similar to No. 8, perhaps a little better	2′	3″
15.	Coaly shale	} 3′	
16.	Concretionary shale		
17.	Coal, fair	4′	8″
18.	Concretionary shale	1′	6″
19.	Coal		2″
20.	Indistinct concretionary shales alternating with flaky coaly layers ...	12′	

Though this seam, as at present exposed, does not give promise of any considerable supply of first rate coal, it undoubtedly contains much of 3rd or 4th rate quality, which might be easily worked.

Owing to the horizontality of a portion of this seam, and the various rolling dips of other portions, it is impossible to represent its strike and outcrop in one. The line on the map is intended to indicate that the coal is seen throughout the distance marked on the bank of the river, rather than to convey any definite idea of strike.

From this to the mouth of the Patpúriá (Dhariá) stream I did not find any coal-seams, the *coal* marked on the Topographical Survey map south of the site of the deserted village of Pánsidánd having no existence. The principal rocks which are seen are horizontal sandstones, some of the individual beds of which are traceable for several miles.

Seam.

Just beyond the Pátpuriá stream there is a small seam of inferior but burnable coal; the section is—

	Descending.	
Sandstone, about	20′	
Coal	1′	7″
Bluish sandy shales	3′	

After this for about five miles the only rocks seen were sandstones and grits. There is no coal *in situ* at the mouths of either the Ghogor or Bánk, as has been indicated on the Topographical Survey map.

Seam.

At the Koteá and Bhojá road-crossing there is a seam containing about 2′ 11″ of poor coaly shale. It is seen again in the adjoining stream on the east. Where seen in the Máhán it has been let in between sandstones by two small faults. The tops of two other seams are exposed in the two next reaches, at the localities indicated on the map. What the thickness and quality of the coal may be which they contain can only be determined by excavation.

Two seams.

There is no coal at either of the localities marked near the mouth of the Gálphúlá.

In the long south-to-north reach which follows, the lower portion of a seam is exposed, paving the bed of the river for about two miles. A clear section of the top of this seam is exposed near Bhagárá.

Seam.

Seam—Descending.

	Sandstone, about ...	12′	
1.	Blue shale ...	?	
2.	Coal, portions shaly, but for the most part fair ...	4′	
3	Blue shale ...		4½″
4.	Coal, fair, upper 3″ stony ...	1′	1″
5.	Shale ...	1′	4″
6.	Coal like No 4 ...		3″
7.	Shale ...		8″
8.	Coal like No. 4 ...		3″
9.	Blue shale, about ...	1′	8″
10.	Carbonaceous shale ...		3″
11.	Coal like No. 4 ...		?
12.	Shale,—covered.		

Some experiments with No. 4 showed that it does not coke, but retains its shaly shape. On roasting, it evolved gas freely in quantity, see p. 39.

The east-to-west reach beyond this has a deep channel, which retains a considerable body of water. This and a dense grass and tree jungle which clothes the sides render it almost impossible to keep the river in sight.

At the bend to the next reach there is a seam which is possibly only another outcrop of the one just described at Bhagárá. However, it contains less coal, and the constituent layers of coal and shale do not correspond.

Seam.

Section—Descending.

	Felspathic grit sandstone.		
	Interval.		
1.	Blue shale ...	1′	
2.	Coaly " ...	1′	3″
3.	Blue " ...	1′	4″
4.	Coaly " ...		4″
5.	*Coal*, fair ...	2′	2″
6.	Blue shale ...	3′	
7.	Coaly shale ...	1′	2″
8.	Coarse grey and blue shales ...	2′	4″
9.	Coaly carbonaceous shale ...	1′	
10.	Shale.		
	Base covered.		

From this northwards to its junction with the Bánki (Pertabpúr) river, the Máhán exposes sandstones at intervals; east of Durti a fine trap dyke causes a fall in the river. The strike of this dyke in the bed of the river is 15° north of east to 15° south of west. A possible continuation of it is seen in the Johoá, six miles to the west; but in the intervening country and also to the east of the river I could see no trace of it.

Trap.

Beyond the junction with the Bánki, under the eastern bank, there is a small seam which contains some hard coaly shale, but apparently no coal. After this for nearly a mile there are Barákar sandstones; and then no rocks are seen for nearly a mile, the deep channel of the river being filled with water. The first rocks exposed are some Tálchír boulder beds, which crop out from underneath the western bank. The faulted junction is therefore hidden here, but is very plain in sections both on the east and west. North of this the Máhán does not again traverse Barákar rocks.

Seam.

Taking up the tributaries of the Máhán, in regular succession from east to west, the first to be noticed is the Dekiá.

Dekiá River Section.—South-west of Markátánd a nearly horizontal seam of from 1′6″ to 2′ of coaly shale and coal crops out at several places. Above it are ferruginous pebble beds and concretionary iron bands, the former resembling rocks occurring in the upper group, *e. g.*, in the hills near Kussumbi on the Ranchi road.

Seam.

Gagur River Section.—Although Barákars occur east of the cross-fault above described, the river section of these rocks commences at it. They consist of massive sandstones, which are horizontal or only slightly rolling, and are deeply cut by the river. North-west of Udukátrá, a seam of coal is partially exposed on the southern bank underlying these sandstones. Apparently the same seam is again seen at the loop bend east-north-east of Burká-Dhuriá; it there underlies some much honey-combed sandstone. The thickness of coal is about 2′ 4″. At the next reach there is another badly seen seam. Throughout the remainder of the section up to the Máhán the rocks are all coarse sandstones.

Seam.

Seam.

The small streams flowing into the Gágur on the south were not examined in detail, but where crossed, they showed no signs of containing coal. They for the most part are at a higher level than the Gágur channel, and have not yet cut down to the coal exposed in it. The watershed where they take their rise is the spur of quartzite which penetrates the Barákar area, and which has been already referred to.

Patpúriá River Section.—The Patpúriá stream rises in the high ground of the quartzite spur below Dhuriá, where it passes on to the Barákars. The rocks exposed are of very peculiar appearance; they consist of pebble-beds and coarse conglomerates, which latter contain masses of blue quartz, jasper, and jasper breccia, derived from the sub-metamorphics in the vicinity. Not far off a large fragment of coal was seen, but no seam from whence it could have been derived was discovered. Half a mile from the mouth of this river there is a seam of coal which measures 2′ 11 ; it underlies massive sandstones, and is not improbably a thickened continuation of the seam described in the Máhán section on page 32.

Seam.

The stream east of Khargáoná, which joins the Patpúriá near its mouth, passes underground for some distance east-north-east of the village. At the base of the tunnel a seam of about 1′ 6″ of poor coal, possibly the same as the one in the Máhán and Patpúriá, is exposed. My attention was drawn to this peculiar tunnel by a flock of blue pigeons suddenly rising out of a hole near the road. This hole proved to be an entrance to the cavern, the existence of which I might otherwise not have suspected.

Seam.

Turrá River Section.—The Turrá river, as well as its tributary, takes its rise in the ridge of metamorphic rocks outside the northern boundary of the field, and joins the Máhán rather more than one mile west-south-west of Kertá.

A short distance from the mouth there is a seam under a thick bed of sandstones which contains about 11″ of inferior coal. About half a mile further up the stream, there is a flat seam containing coaly and carbonaceous shales, the thickness of which is uncertain. The map not being plotted, I am unable to say to what exact spot the next locality for *coal* marked on the topographical map may refer. Somewhere in that neighbourhood there are traces of carbonaceous shale, but no coal. Like so many others in Sirgújá, this river proved very difficult to follow up: throughout long reaches the accumulation of the water in the deeply cut sandstone channel rendered it impossible to wade, and the thickness of the jungle on the ravine-intersected banks made it almost equally impossible to keep along the bank in sight of the rocks.

Seam.

The next coal seam exposed is situated slightly south of west of Chourá. It is flat, and paves the bed of the river; portions are coaly, but the thickness is not disclosed.

Seam.

In the western branch of the Turrá called the Gohogor, I saw no traces of coal at the junction. But the river has not been examined.

Bánk River Section.—The Bánk river rises in the metamorphic hills to the east of Bisrámpúr, and joins the Máhán north of Bhojá. It first enters the sedimentary rocks (Tálchírs) near the village of Tákiá. Thence it proceeds northwards along the eastern boundary of the field, bending at one locality into the Barákars, and at another into the metamorphics, and for the remainder of its course up to Ghangri, traversing Tálchírs.

In the Bhiti river, which joins it close by, there is a seam of carbonaceous shale which is seen at the road-crossing below Bakná. In a stream which joins the Bhiti south-east of Bakná, there is another seam containing about 1′ 6″ inches of coaly shale; this is covered by coarse sandstones, the exact position of the boundary between which and the slates is hidden. Returning to the Bánk, the Tálchírs, which occur in the bed of the river north of Ghangri, are gradually covered by pebbly Barákar grits. About a mile from the junction, there is a seam containing about 5″ of good coal; after this, half a mile further, there is a rolling seam which contains 2′ 10″ of shaly coal; it is several times repeated higher up. West-south-west of Abkorá, there is a seam which is exposed by the deep-cut channel included between massive beds of grit. It has a slight inclination to north and a variable thickness, the average being about 2′; it is, like many other of the seams in Sirgújá, in all probability only a lenticular mass with limited lateral extension.

Seam.

Seam.

Seam.

For about two miles beyond this only sandstones and grits are exposed. But east of Chátásárái there is a seam of shaly coal of which 2′ 1″ is exposed, the base being hidden. The streams which join the Bánk in this neighbourhood from the east did not, at their mouths and for some distance in, give any promise of coal. At the point where the Partábpúr and Bisrámpúr road crosses the Bánk there is a seam, with a slight dip to the south-east, which contains about 8′ of poor flaky coal and carbonaceous shale exposed, the base being hidden. In a stream which joins the Bánk north of Ráimá, there is a seam containing somewhat similar shales. Nearly north-west of the deserted village of Chora, there is another seam with the same constituents; of this 2′ 6″ only is exposed.

Seam.

Seam.

Seam.

For about two and a half miles more the river runs along through a gorge cut in q. p. horizontal beds of massive sandstones and pebbly grits. Nearly due east of Bhojá there is a seam of coal dipping 5° to north, in which there is about 1′ 8″ of coal exposed.

Seam.

The remaining two miles or so of the Bánk, up to its junction with the Máhán, I was prevented from examining by an attack of fever.

Koteá River Section.—In the stream which joins the Máhán south of Koteá, the rocks are much covered, especially near Gourá. East of Koteá, there are sandstones; and close to the mouth there is a section of the seam which is seen in the Máhán, vide p. 32.

Galphúlá River Section.—In the loop-bend of the Galphúlá near Biláro there is a seam containing some coal, about 8″ of which is seen. In an adjoining stream the whole seam, measuring about 7′, is exposed, in which there are seen to be coaly layers mixed up with carbonaceous shales. I do not

Seam.

think there is any promise of good coal being found in workable quantity. This seam has a more decided dip to the north-east than is common, the rocks being for the most part horizontal. Coal was met with south of the deserted village of Jhaprá. The seam consists of carbonaceous shales, with thin layers of coal, one near the base measuring 6″; the dip is 10° to south-east.

Seam.

The same seam is better seen in the Báherádol branch of the river; it is here seen to be of considerable size, and contains about 6½ feet of fair coal. Some of the accompanying shales contain *Glossopteris* and other plant fossils.

Fossils.

There are several other seams containing carbonaceous shale, with portions coaly. One is situated west of Jhaprá and another west of Bhojá; the character of the latter hardly justifies the insertion of *coal* on the Topographical Survey maps.

Seams.

Jhampi River Section.—In the Jhampi from Doin to its junction with the Máhán I only met with one seam of carbonaceous shale associated with the Barákar sandstones. Some fragments of coal, however, indicated the presence of a seam in the area drained by the numerous small tributaries.

Seam.

Chengodri River Section.—From the character of this river and its banks it was absolutely impossible to follow it up closely. The only seam I met with, was one containing 1′ 1″ of coal which is situated at the junction with the Jhámpi.

Seam.

Másán river Section.—As indicated on the Topographical Survey map there is coal in the Másán north-north-east of Járhi; the total thickness of the seam is about 7′, of which 2′ is coal. It dips to north-east. From its more shaly and generally inferior character, I am inclined to think it is distinct from the seam about to be mentioned. This seam runs with the stream for a considerable distance, being last exposed about half a mile from the junction with the Máhán; it contains from 5 to 6 feet of coal, the upper portion of which is very fair. It has an unsteady dip to south-south-west, which never exceeds, and rarely attains 10°. This is the most promising seam in this part of the field.

Seam.

Seam.

Bánki (Partábpúr) River Section.—The boundary of the coal-field crosses the Bánki about two miles north-north-west of Bardhá. The section clearly shows it to be faulted; the edges of the sandstones are presented against the faces of some much tilted and disturbed slates and quartzites, the penetration of which by granite-veins and their relations to the granitic gneissose rocks I shall allude to further on. At the junction on the western bank of the river a thin band of 7″ of coal underlies the topmost sandstone, and is itself underlaid by a greenish yellow sandstone, which I at first thought might be Tálchír, but subsequently concluded to be Barákar.

Seam.

From this to the junction with the Máhán there are more or less horizontal sandstones.

In the Daldali stream, nearly due north of Burdhá, there is a seam of coaly and carbonaceous shale, which with its accompanying sandstones is (locally) upheaved to an angle of 45°; from this to the point where the stream passes into the Tálchírs sandstones only are seen.

Seam.

Nákti River Section.—The Nákti for a portion of its course runs with the faulted boundary of the Barákars, crossing and recrossing it frequently. The only rocks of this group which it exposes are sandstones. In the Márátá branch of the stream there is a small seam of coaly shale of no importance.

Seam.

The Barákar faulted boundary leaving the Nákti north of Narkolá is traceable south of Pakni to Károti, where it is cut off. In several places along it the sandstones are highly indurated.

Rehr River Section.—The Rehr river with its tributaries drains the south-western portion of the coal-field.

The bounding fault of the south-west corner of the Barákars of the Bisrámpúr area crosses the Rehr one mile north-east of Beltikri; the actual junction line is here covered, but Barákars and Tálchírs are exposed at no great distance on either side.

Trap.

In the reach which strikes eastwards from Pachirá there is a trap dyke, which for a mile forms the northern bank of the river; at the other end it is flung by a small cross fault which brings it down to the southern bank. Besides this principal dyke there is a second, irregularly parallel to it, which traverses the sandstones for a short distance.

Seam.

In the next reach there is a coal-seam containing about 18 inches of fair coal. Dip 5° to north-east. Further on there is seam which is, I think, distinct from the last. It is inaccessible, being under a thick bed of sandstone which overhangs a deep pool. It is probably from 15″-18″ thick. Rather less than a mile beyond the junction with the Pasang there is a seam exposed in the bed of the Rehr, of which the measurable thickness is about 3 feet. It has a slight dip, which varies in direction between east and north-east. Most of the coal is fair, and a portion excellent. In the bed of the river beyond this, blocks of coal of considerable size—from what seam derived is uncertain—are abundant and of good quality. They may have been washed out of the seam just mentioned, or carried in from some of the seams in the Pasang. Beyond this seam, up to the boundary, the only rocks seen are coarse Barákar sandstones.

Seam.

Pasang River Section.—East of the Silphili Ghát, the section in the Pasang for about four miles exposes horizontal sandstones only. The same beds persisting throughout.

Seam.

West of the ghát the same sandstones continue for about four miles. In some places the river has cut for itself a deep channel. South of the deserted village of Kasalgiri there is a seam which at first, from the manner of weathering, appears to consist entirely of good coal. On close examination, however, more than half proves to be quite useless, and the remainder inferior earthy coal.

Section—

1.	Carbonaceous shales	8″
2.	Shales with plant fossils	2″
3.	Carbonaceous shale, passing into	1′ 5″
4.	Earthy coal	2′
		4′ 3″

Four seams.

At the mouth of the Chapar river there is a seam, which, so far as it is exposed, consists of slaty carbonaceous shale, with portions coaly. Before the mouth of the next northern tributary there is an inconsiderable seam of coaly shale, which has been locally tilted. Immediately after it the top of another seam is seen under water. Before reaching the mouth of the Ársothá tributary, the top of another seam, containing about 1′ 6″ of coal, is seen at the water's edge, and underlying the massive sandstone through which the channel is cut. This, or a distinct seam, is exposed in the reaches beyond the Ársothá stream; it contains 3′ of coal and coaly shale, possibly more.

Seam.

From this up to the mouth of the Karchá the rocks are covered. But a short distance beyond it a seam is imperfectly seen under the southern bank. Possibly a continuation of the same is exposed at the mouth of

a stream which joins the Pasang near the Jáinnuggur and Kúmdá road. It there contains 1′ 6″ of good coal (*vide* p. 39). The top is much weathered, and covered with soil, but the base is well seen. Another seam is badly exposed west of the road, after which up to the junction with the Rehr the only rocks seen are horizontal sandstones. In the Khoá and Gambadiá rivers west of Pilká the Barákar sections contain grits and sandstones only; the latter are sometimes of a somewhat pinkish color, as also are some of those in the Pasang associated with the coal.

Seam.

Gobri River Section, &c.—The character of the sections in the Gobri, with its tributaries the Dámundá, Patpúriá, and Kadáriá, can be best gathered from the map. In so far as the Barákars are concerned, there are no points of sufficient interest to be made the subject of special detail. No traces of coal were met with in any of them.

IV.—Upper Sandstones (Lower Máhádevás?)

Within the limits of the Bisrámpúr coal-measure area, the only locality in which sandstones referable to any of the groups higher than the Barákars occur, is in the Pilká hills, a remarkable looking cluster which stands out isolated in the centre of the Sirgújá plains.

Pilká hills.

These hills are formed of hard quartzose sandstones, grits and pebble conglomerates, the beds of which are horizontal; and the elevation of the top of the highest hill above its base, or about 1,000, may therefore be taken as giving the total thickness.

Thickness.

The evidence here afforded of great unconformity between the rocks of this and the older formations is singularly conclusive. The basal bed of grit laps from Barákars across Tálchírs on to metamorphics, the relations between which had been first established by faults. A doubtful case—not yet fully examined—of similar faulting having taken place in the Barákars previous to the deposition of the upper sandstones, occurs in the hills to the north-east.

Unconformity.

In the Káranpúrá field too, a fault has been mapped as running under the Upper Pánchets.

In describing these rocks, I follow what appears to be now the accepted belief, *viz.*, that the Upper Pánchets of the Damúdá fields are of Lower Máhádevá age, and the general lithological resemblance between the Pilká grits, &c., and the Upper Pánchets, is so strong that I think their identity may be safely asserted.

The only difference that I could detect between the pebbly beds of Pilká and those of Panchet and Lúgú* was that the former are somewhat less ferruginous, in which respect they resemble the Rájmahál grits, which appear to be also referable to Máhádevá age.

On the level top of the hill there is a little soil, but no trace of either laterite or trap. Judging from the similar hills and the plateaus, both to the north and south, trap in all probability at one time did also exist here.

No laterite or trap.

Trap Dykes.

In addition to the general horizontality of the beds, and the small throws of the few faults in the Bisrámpúr coal measure area, the scarcity of trap dykes affords evidence that the rocks have been subjected to a very small amount of disturbance, as compared to that which has affected the more eastern fields.

One trap dyke is exposed in the Máhán section, two miles east of Durti. A possible continuation of it is seen in the Tálchírs and metamorphics, in the Jojhoá stream, seven miles to the west, but no other trace of its continuance beyond the bed of the Máhán was discovered.

Máhán dyke.

* Hills situated respectively in the Ràniganj and Bokáro fields.

The only other trap dyke is seen in the Rehr section, where it runs for about a mile along the northern bank of the river, below Pachirá. At the east end of the reach it has been flung to south by a small fault.

Rehr dyke.

Both the above are coarsely crystalline diorites.

V.—ECONOMIC RESOURCES.

Building stones.

With the exception of building stones which are of the usual character found in the Barákar and Tálchír rocks, the economic resources of the Bisrámpúr coal-field are limited to coal.

Many seams worthless.

From the imperfection of the sections, and the difficulty of identifying the partially exposed coal seams at different localities, any attempt at a tabular statement of the number of seams would only tend to exaggerate the importance of a large proportion of them, which, while they will in all probability prove to be worthless, cannot at present, from the limited data which we possess regarding them, be individually asserted to be so.

Good coal.

Borings.

It may be regarded as an established fact that good coal does exist in fair abundance, and from the horizontality of the seams, in a suitable condition for working. But borings can alone furnish facts sufficiently reliable for estimating the extent and thickness of individual seams, and generally the total amount of coal existing in the field. Such borings at a few well selected sites, would, in consequence of the undisturbed character of the beds, and the comparatively small thickness of the whole formation, give conclusive and exhaustive information as to the amount of coal obtainable.

Points for boring.

To prove the individual seams which, as at present exposed, are the most promising, I would recommend borings being made on the west bank of the Máhán, a mile and a half north of Chendiá; on both banks of the Máhán at Bhagárá, and on the southern bank of the Pasang, north of Jaldegá; and from these points in whatever directions the original results would render it probable that the seams extended.

For proving the total amount of coal throughout the area occupied by the coal measures, borings should be made all across it. It is at present hardly necessary, however, to go further into the question, as the probability of this hill-surrounded area being ever the seat of mining enterprise is so slight that the existence of coal there in whatever quantity can hardly be said to have any immediate importance from an economic point of view.

The coal-fields below the plateau in the Mánd valley, ninety miles to the south, are the only localities in Western Chotá Nágpúr which are ever likely to be made use of by any railway connecting Calcutta and the Central Provinces.

The following is the result of the assays of coals from five localities :—

	COAL SEAMS.	CARBON.	VOLATILE.	ASH.
1.	Rehr river near Panri ... ... (water 5·5)	57·7	38·2	4·1
2.	Pasang river, Jáinuggur and Kumdá road	56·2	37	6·8
3.	Máhán „ Bhagárá	50·2	33	16·8
4.	„ „ north of Chendiá	48·5	32·4	19·1
5.	Másán „ ... ... (water 4)	45·5	31·6	22·9

VI.—Metamorphic Rocks.

Two groups.

The metamorphic rocks surrounding the Bisrámpúr coal-field are separable into two groups, chiefly by their respective lithological characters. But their occurrence here, as well as in other parts of Chota Nágpúr, is accompanied by certain geological features, which render it probable that they really belong to two different periods.

Types.

The types of the former group are coarse granitic gneisses with variable amounts of visible foliation. Of the latter the types are slates, quartzites, and hornblendics. Instances occur however where individual beds, lithologically undistinguishable from the latter, are geologically inseparable from beds belonging undoubtedly to the former.

VII.—Granitic Gneiss Series.

The east and west range of hills south of Partábpúr, which bounds the coal-measure rocks on the north, consists of coarse granitic gneisses and schists which are exposed in section in the Máhán, Bánki, and Rehr rivers; in the Bánki section, however, there are also some quartzites, to which allusion will be made again further on.

Trap-like hornblendics.

On the east face of the field, granitic and porphyritic gneisses are again met with near Árá, where they occupy a zone about three miles wide. South of these a peculiar group of trap-like hornblendic rocks form the high ground near Pársá. At first I was strongly inclined to believe these to be trappean, and only relinquished this opinion on finding traces of foliation in some of the sections exposed in the streams on the top of the hill. These rocks continue to the Bánk south of Sonpúr.

Spurs.

The spurs from the high ground east of Bisrámpúr are formed of granitic gneisses with occasional schistose, hornblendic, and quartzose bands.

South-west of Bisrámpúr and south of the Pilká hills, there is an area occupied by metamorphics, which consist chiefly of granitic gneisses. These extend southwards to the Máin pât through Lukánpúr.

Section in Rehr

On the west of the field the section of the metamorphic rocks in the Rehr commences with quartzites of rather uncertain affinities; these are followed by granitic rocks, which continue—occasionally including schistose or slaty beds—up to Jhilmilli.

VIII.—Quartzite and Slate Series.

Section in Bánki.

North of the faulted boundary where it crosses the Bánki, there is a thickness of several hundred feet of quartzites and slates, which present a somewhat very unusual appearance. Granite veins or dykes which are ordinarily confined to the gneissose rocks, in this case pass across into the quartzites, and appear to have been the cause of the disrupted and tilted condition of the beds. In some cases fragments seem to have been torn off from the main mass and are enveloped in the granite. Accompanying this disturbance the slates are much hardened, and the faces are lustrous with crystals of actinolite.

Rocks hardened.

On the eastern side of the field, rather more than half the length of the boundary runs between Tálchírs, quartzites, slates and schists. The extreme irregularity of the surface

of the latter at the period of the deposition of the Tálchírs is well shown by the broken character of the boundaries. In the Gehur and Máhán sections many of the slates abound in iron pyrites, which is generally decomposed near the surface and covers the rocks with a copious efflorescence of sulphur. I saw no traces of copper, but from the similarity of the rocks to the copper-bearing beds of Singhbhúm, it is by no means improbable that it may exist.

Iron pyrites.

The Gágar river south of Kárnji traverses a deep gorge, and gives an admirable section of the nearly vertical rocks through which it passes. They consist of slates, indurated shales, quartzites and hornblendics, the last mentioned sometimes exhibiting a cannon ball structure.

One slightly calcareous slate contained a few striated moulds, or impressions of apparently organic objects, but what they could have been has not been determined.

Organic impressions?

A steady strike to nearly west-north-west east-south-east prevails in these rocks. Where not vertical, the dip is to south-south-west at a high angle.

Near the village of Kuthwán, interbedded with quartzites, &c., there is a conglomerate formed of rounded fragments of quartzite, jasper, &c., bound together by a very hard quartzose paste.

Conglomerate.

A spur of quartzites, &c., penetrates for six miles west of the main boundary at Chanchi into the basin. It is not now covered by the sedimentary rocks; indeed south of Dariá it forms some small hills which rise above the general level.

In the stream south of Daria, V. S., the conglomerate just mentioned is again seen; it is on exactly the same strike as the portion of it which is near Kuthwan, or nine miles off.

At Ara, as already mentioned, the granites come in, cutting off the slates. On or about the line of junction, there is a run of limestone, which contains crystals of tremolite.

Limestone.

West of the Pilká hill there are quartzites, which must, I think, be referred to this group; and the hills south of Pahárbullá consist of rocks of the same character.

One notable difference I observe between the rocks of this group as seen in Mánbhúm and Singhbhúm and in Sirgújá, and that is, that the varieties of magnesian schist which are common in the former and furnish a considerable proportion of the total thickness, are nearly altogether absent in the latter.

Absence of magnesian schists.

MINERALOGICAL NOTES ON THE GNEISS OF SOUTH MIRZÁPÚR AND ADJOINING COUNTRY, *by* F. R. MALLET, F. G. S., *Geological Survey of India, (No. II.)*

Limestones.

Having last season found the limestone of the Bíchí nadí* to be a normal dolomite, I collected specimens from various localities this year, in order to ascertain how far this character is general in the limestones of the gneissose series. On analysis I obtained the following results:—

I.—Calcite Limestones.

	A.	B.	C.
Carb. of lime	97·92	83·12	85·92
" " magnesia	1·47	7·04	8·19
" " iron	·38	1·28†	·76
Insoluble	·80	10·16	5·52
	100·57	101·60	100·39

II.—Dolomite Limestones.

	D.	E.	F.
Carb. of lime	67·28	64·68	53·85
" " magnesia	30·24	34·14	45·78
" " iron	·78	·58	·34
Insoluble	·50	·76	1·00‡
	98·80	100·16	100·97

A is a very coarsely crystalline white limestone, from south of Bilwáda on the road from Singraulí to Mirzápúr; B a dark grey fine-grained crystalline rock, from east of Karámi, (sheet 18, Ríwa Survey); C is a white and greenish-white, rather fine-grained crystalline rock, which occurs in subordinate beds through the dolomite E. It weathers with a smoother surface, and is tougher on account of its more compact texture. D is a rather finely crystalline, or saccharine, white dolomite, from the banks of the Rehr, south-west of Ekpai; its composition corresponds nearly to the formula $2CaO, CO_2 + MgO, CO_2$. E is a white rather coarsely crystalline rock from north of Parárwa, having the composition $3CaO, CO_2 + 2MgO, CO_2$; while F is the white crystalline normal dolomite ($CaO, CO_2 + MgO, CO_2$) of the Bíchí nadí already referred to.

It will thus be seen that the limestones vary from pure carbonate of lime to pure dolomite. In some cases, of which C and E are examples, the two rocks are interstratified. The above dolomitic limestones are all associated with more or less serpentine; and I think it may be assumed that where the latter mineral is present in any quantity, the limestone is magnesian. In the only case I have hitherto observed in which serpentine is actually interbanded with the limestone the latter is true dolomite.

Wollastonite.

In the two patches of gneiss east of Koelkat (sheet 18) occurring as inliers in the Tálchírs, limestone is very abundantly met with, the same beds being probably repeated by folding, with a general strike of about west 30° north. It is a white crystalline rock, varying from a saccharine variety to one with cleavage facets of ½ inch across. The band to east of Ráondí contains a very large amount of wollastonite. In fact the rock is entirely composed of this mineral in places, constituting there a 'wollastonite schist,' which from its greater resistance to atmospheric

* Vol. V, P. 19. † With traces of manganese. ‡ Chiefly minute scales of mica.

influences often stands up above the general surface in a low jagged ridge. The mineral has a greyish-white color and bright pearly lustre, and the approximate parallelism of the principal cleavage faces gives the rock a somewhat fissile structure. Tremolite is very abundant in the limestone of the Bíchí nadí ;* but the above is the first instance I have met with of the occurrence of wollastonite.

Corundum.

My work brought me again this year to the corundum quarries between Pípra and Kádopání, which I examined closely. The thickness of the bed cannot be determined with any degree of accuracy from the amount of *débris* lying about; but as a rough guess I thought I was more below than above the mark in estimating it at 30 yards at the quarries where it appears to be thickest, and it may be considerably more. The ground is too obscure for one to say with certainty that the above includes no subordinate layers of other rocks, but I observed no indication of such, and for anything I saw for the contrary, the bed may be a solid mass of corundum. It runs about east-north-east, west-south-west, the bedding being vertical or at a high angle. The section previously given† is only true for the spot where it was made, for some of the associated beds die out rapidly. At the west end of the long low hillock which marks the position of the mineral, porphyritic gneiss and white quartz-schist are seen within 10 yards of each other with corundum in the space between. From this to the Rehr, some 300 yards, is obscured by clay, and no trace of the corundum is to be found in the river. East of the quarries again, the bed can only be followed for a short distance, the entire length visible from west to east being, as laid down on the map, about half a mile.

The corundum, where weathered, much resembles fine-grained hornblende-rock in a similar state, and might be easily overlooked. Its intense hardness is well shown by the way in which hammers which may have stood years of ordinary geological work are in a few minutes split and pounded out of shape on it. It seems strange that it should not form a more prominent physical feature. Pluvial mechanical erosion would apparently act very slowly indeed on it, in comparison with the softer rocks on either side, and the absence of secondary minerals in considerable quantity does not point to important chemical alteration. Probably its weak point is the irregular jointing by which it is intersected.

The quarrymen are, I was told, paid at the rate of one rupee per 31½ kacha mánds raised, but the mineral is only worked now and then when a quantity is ordered by the mahájans who deal in it. Before commencing operations a kid is sacrificed to Deví, to insure good fortune, and protection from accident; fires are lighted against the large masses into which the corundum is divided by jointing, and when they have been rendered somewhat more brittle by this means, they are gradually smashed by heaving other pieces at them. Considering the thickness and length of the bed, it is clear that the supply may be considered inexhaustible.

I have described the minerals which are associated with the corundum in my previous note. The only additional species I have observed this year is kyanite, which occurs in a radiating aggregate of a reddish color. It is a mineral, which as a simple silicate of alumina, is a natural associate for corundum, and has been similarly met with elsewhere. There are also small bladed crystals with a bright pearly lustre, much like diaspore, but their small size and the impossibility of detaching them makes their examination difficult. They may be kyanite.

Magnetite.

Beds of magnetite interlaminated with granular silicious layers are met with not unfrequently, more noticeably in the crystalline inliers near Koelkat, also near Gairár and south of Kádopání. None of these, however, are as rich in iron as the magnetic band at Korché in Mirzápúr.‡ Magnetic sand very

* Vol. V, P. 20. † Vol. V, P. 20. ‡ Vol. V, P. 22.

frequently accompanies other arenaceous materials in the beds of watercourses, n some cases probably in sufficient abundance to repay collection by the native iron-smelters. The difference in specific gravity causes a natural separation of the ferruginous and silicious grains, so that the former could be collected with only a moderate percentage of foreign matter, which could be almost wholly eliminated by washing. As far as I am aware however, no attempt is made to utilize this rich detrital ore, while a few miles to the north, the vastly inferior ferruginous beds of the Barákar sandstones are laid under contribution.

ERRATA IN PREVIOUS NOTE, (Vol. V, page 18).

Page	18,	line	8, from bottom,	*for*	Hæmatite	*read*	Tremolite.
„	20,	„	3,	„	say	„	vary.
„	„	„	12,	„	chrysolite	„	chrysotile.
„	„	„	5, from bottom,	„	and	„	to finely.
„	21,	„	21,	„	or in any	„	or any.
„	22,	„	4,	„	starry	„	strong.
„	„	„	5,	„	falls	„	fuses.
„	„	„	11,	„	white	„	rutile.

DONATIONS TO THE MUSEUM.

January 23rd.—Colonel J. Stevenson, Deputy Commissioner of Akyab.—An ancient stone implement of Akyab district.

February 26th.—F. R. Mallet.—A specimen of arsenious acid from Orissa, (artificial).

„ 28th.—Major Montgomerie.—A few nummulitic fossils from north-east of Lassa, Thibet.

March 31st.—H. Woodward, Esq., f. g. s.—Two casts (upper and under surface) of Eophrynus (Curculioides) Prestvicii from coal-measures clay iron stone, Dudley, (Geol. Mag., 1871, Vol. VIII, pl. XI).

ACCESSIONS TO THE LIBRARY.

From 1st January to 31st March 1873.

Titles of Books. *Donors.*

Bell, J., Lowshian.—Chemical phenomena of iron smelting, (1872), 8vo., London.

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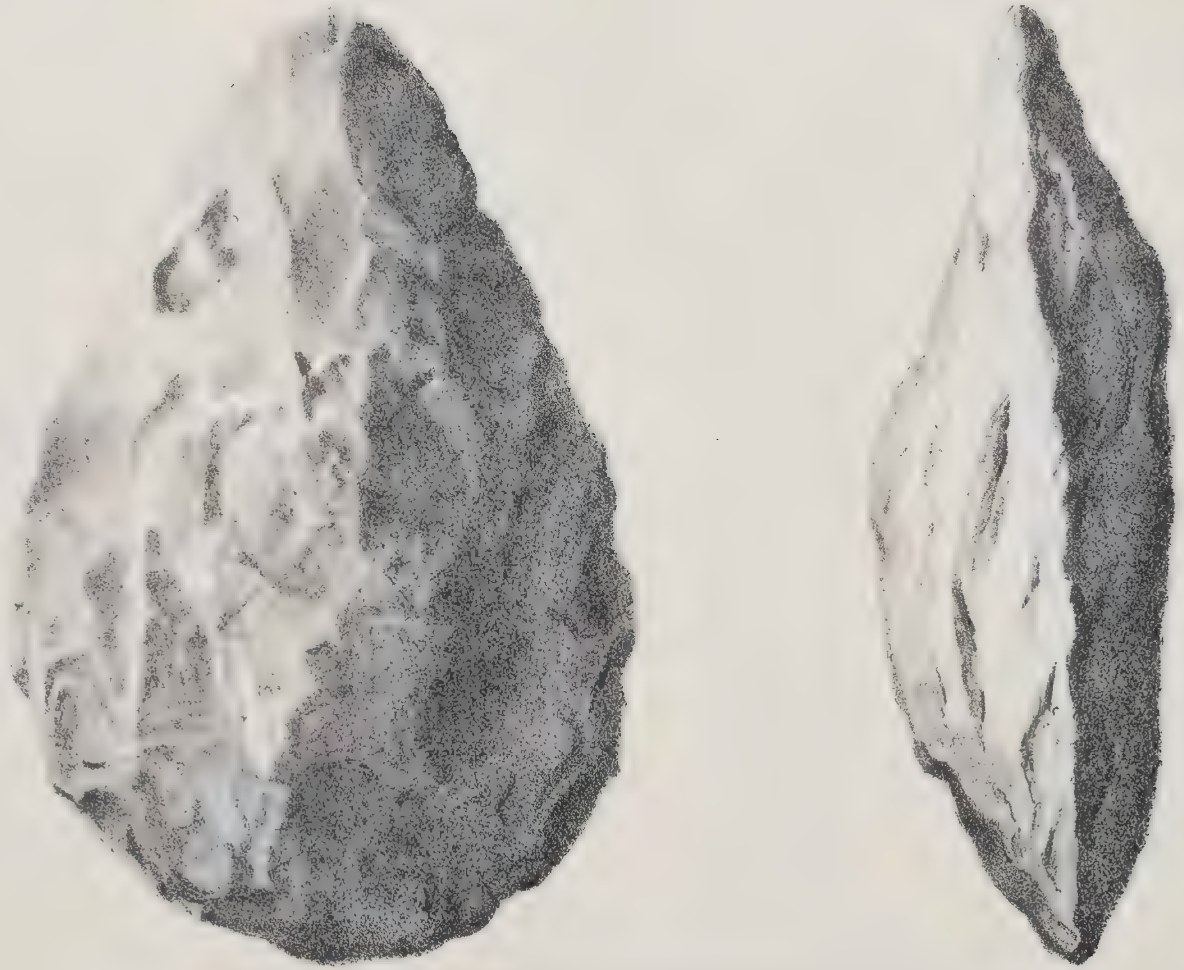

Stone implement found in the fossiliferous clays of the Narbadá Valley, near Bhutrá, 8 miles north of Gádarwára

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1873. [August.

Notes on a Celt *found by* Mr. Hacket *in the* ossiferous deposits *of the* Narbadá Valley (Pliocene *of* Falconer) : *on the* age *of the deposits, by* Mr. H. B. Medlicott ; *on the associated* shells, *by* Mr. W. Theobald.

The celt is formed of Vindhyan quartzite, such as might be procured at any point along the northern edge of the valley; it is of the pointed oval shape, 5″ × 3″⅝, of very symmetrical outline (see figure); and, although rather roughly chipped on the faces, it is unquestionably a manufactured article. Mr. Hacket dug it out himself from where he found it lying flat, and two-thirds buried, in a steep face of the stiff, reddish, mottled, unstratified clay, about six feet above low water level, and about three feet below the upper surface of the clay, upon which there rested about twenty feet of the gravel with bones. From the edge of the cliff of gravel, there is a steep slope passing up through the ravine ground, so common along the border of the main river channels, to the general level of the plains, at 90 to 100 feet above the level of the Narbadá. The locality is on the left bank of the Narbadá, near the village of Bhutra, eight miles due north of Gadarwara.

The age of the ossiferous deposits.—In bringing forward an authentic specimen of human manufacture from the ossiferous deposits of the Narbadá valley, some expression of opinion will be expected from geologists in India regarding the age of those well-known beds; the more so because a name has been already applied to them by a high authority, implying an age very much more remote than that of any human remains as yet found in other countries. In all questions relating to the determination of vertebrate fossils, Dr. Falconer's judgment carries great weight. In India he has not as yet had a competitor in this line of research; and even in Europe he took a leading part in the same studies, connected with the inquiry into the antiquity of man. He determined a number of fossil bones from the Narbadá deposits, and invariably spoke of them as pliocene.

In 1868, the Superintendent of the Geological Survey described in these Records (Vol. I, p. 65,) an agate flake, or knife, found by Mr. Wynne in the ossiferous clays of the Godávarí valley, which he affiliated to like deposits in other parts of India. In this connection Falconer's views were quoted at length by Dr. Oldham in a tone of high approval, without any expression of dissent or of question as to the matter of age; and thus at least a tacit assent and a fresh lease of life was given to the opinion that these deposits belong to the pliocene age of geologists, the name being used by both authors in the confident expectation that these deposits would yield evidence of man's existence. I do not pretend that the question of age can be finally settled now; but it is important to point out that the opinion quoted is not well founded.

For those who are not posted up in such matters, it is well to point out the considerable historical license that is taken in this application of the name pliocene. In the accepted geological nomenclature the tertiary formations end with the newer pliocene. Although the post-tertiary period is as nothing compared with the preceding geological ages, it still represents a great lapse of time, for an estimate of which we are entirely dependent upon geological evidence. After passing the recent, or prehistoric, period, in which all the animals are of existing species, we get into the post-pliocene, or pleistocene, period, in which a variable proportion of the mammalian remains are of extinct species; and according to the distribution of these extinct mammalia, the deposits are arranged into late, middle, and early pleistocene. Nearly all the old river-gravels and cave-deposits with the human remains, about which so much has been published in the last few years, belong to the late pleistocene, or, as it is sometimes called, the quaternary period; this name being sometimes also used as equivalent to the whole pleistocene, and preferably so in my opinion, as distinctly marking its post-tertiary date. Thus it may be said roughly that the oldest human remains in Europe only take us about half-way back in that post-tertiary time. Almost the whole of the glacial period,—during which England was in great part submerged, and the glaciers of the Alps filled the great valley of Switzerland to high up on the flanks of the Jura,—intervenes between those ossiferous valley-gravels and the newer pliocene, or even the early pleistocene. Some supposed evidence of human remains has been brought forward from pliocene strata in England, and even from miocene beds in France, in the form of perforated shells, scratched and split bones, and very rudely-chipped stones; but the correctness of these interpretations has been denied by competent and quite unprejudiced judges.* It may, therefore, be said that from the stand-point of existing information, the genuineness of human remains from pliocene strata, or the true pliocene age of strata containing human remains, would call for particular proof; or, not to disguise the point, supposing (as seems almost probable) man to be an exalted chimpanzee, it is quite an open question whether the change may not have occurred in post-tertiary times—so little positive is still our knowledge of geologic time and of the method of organic evolution.

Even some geologists seem to need to be reminded that the tertiary period and its sub-divisions are based upon the testacea only, upon the proportion of living to extinct species of fossil shells, not of fossil remains in general. The fitness of this limitation was guaranteed in the first instance by the judgment of its distinguished author; and it has been justified by the universal adoption of the classification based upon it. It is with no small astonishment, therefore, that we hear of the grounds given by Falconer for calling the older deposits of the Indian rivers pliocene. After telling us (Pal. Mem., Vol. II, p. 644), on the authority of the Geological Survey, that the shells are all of existing forms, although in somewhat different proportions to those now inhabiting the Narbadá valley, he adds:—"In designating the formation as pliocene, which I have done during many years, I have been guided by the indications of the mammalian fauna, as intermediate between the miocene of the Irrawadi, Perim Island, and the Sivalik hills, and that of the existing period." That is, he takes upon himself to use the word pliocene in a sense quite foreign to that in universal use. The difference noticed here in the relative strength of the molluscan species in the living and the fossil stages is nothing like so great as that in the post-pliocene deposits of Europe. For the living relations of some of the species, even in the late pleistocene deposits of England, one has to go to the Mediterranean or to sub-arctic waters. The whole ground of Falconer's position is placed upon the mammalian fauna. The act is thus either a deliberate attempt to revolutionise the meaning of part of our best established geological nomenclature, or else the word pliocene is applied in a more abstract sense, im-

* Opinion may be reserved at present upon the miocene age of Mr. Calvert's fossil drawings.

plying that these deposits in India belong to the age of the pliocene of Europe. Falconer cannot be acquitted of the grave error involved in the former position; and one scarcely knows whether the error is aggravated or palliated by the fact that his judgment was here influenced by his temper. It is painfully evident in his later writings that he took a pleasure in ignoring and crossing the authority of Sir Charles Lyell. It was not only to Indian deposits that Falconer applied his independent criterion of classification: upon the evidence of the fossil mammalia he designated the well-known pre-glacial forest-bed of Norfolk as pliocene, in defiance of established usage (loc. cit., Vol. II, pp. 190, 586). One need hardly say that his attempt has been by common consent ignored. In a very recent note upon the classification of the pleistocene deposits, Dr. Boyd Dawkins points out the very marked difference even of the mammalia of the forest-bed from that of the pliocene (Am. Jour., April 1873).

The hint thus given to geologists in India is a very strong one; and the matter would scarcely have been worth notice but for the apparent sanction recently given to Falconer's words. We are in a manner bound to reject Falconer's criterion as such; and it only remains to be seen whether in some non-regulation sense the Narbadá deposits, and with them the old alluvium of the Gangetic plains, can be of pliocene age. It is of course conceivable, albeit in contravention of the harmonies of nature so far as known, that the mammalian fauna might be very strongly in favor of the position taken up by Falconer. Although the fossil shells all belong to species now living in the neighbourhood, the mammalian forms might (at least in argument) be of such antique types as to bear down the standard of the shells. Nothing of the kind, however, is the case. Falconer repeatedly insists, on the one hand, upon the perfect distinctness of the Narbadá fauna from that of the Sivaliks, and on the other hand, upon its strong affinity to living forms. He speaks of the Narbadá fossils as "in time only a little ahead of existing species" (op. cit., Vol. I, p. 21). He nowhere says that the Narbadá fossils are in any specific sense pliocene; but only, without any attempt at precision, that he calls the deposits pliocene because the mammalian fauna is intermediate between the miocene of the Sivaliks and that of the existing period. It is a great testimony to the authority of Falconer's name that an innovating opinion, without even an attempt at defence, should have met with any consideration. I do not, indeed, presume that Falconer's statement of age has ever received much countenance from students in Europe or elsewhere; but since an apparent approval of it has been issued by a high authority in India, it is well, on so fitting an occasion as the present, to examine the merits of the case.

As regards fossil man in India, Falconer's speculations were based a good deal upon biological assumption and geological misconceptions. It is not quite certain that *à priori* the oldest marks of intelligence that can be called human are to be looked for, as Falconer tells us, "in the great alluvial valleys of tropical or sub-tropical rivers." If the analogy of historical times may be taken into account, it would not be under conditions favorable to nakedness and laziness that we should expect contrivance to be born. We may indeed find the most monstrous form of the ape in the deposits of tropical regions; but it may be quite possible we should look for the earliest trace of humanity in the regions now most favourable to its development.

Mixed up with Falconer's mythical, biological and physico-geographical speculation upon the cradle of the human race in India, there is frequent very vague mention of geological conditions; and here we come upon his weak point. It is an excellent example of a confusion very commonly made—showing how a man may be in the first ranks as a palæontologist, and in that sense a geologist, and yet possibly be a very poor geologist in the stricter and primary sense of the word. Although Falconer's clear instinct

of observation led him to the broad conclusion that the Sivalik strata were formed of débris conveyed through the existing river-channels (op. cit., Vol. I, p. 8), and deposited along the base of the mountains, it may almost be said that he never made a geological observation in any particular sense of the action. The most amazing instance of this appears in the explanation he gives of the absence of lakes along the base of the Himalaya, as compared with the Alps. He tells us (op. cit., Vol. II, p. 650,) that for ten or twelve years he puzzled over this problem on the ground; yet he accounts for the absence of lakes along the base of the Himalaya by there never having been glaciers to prevent the silting up of the basins. The absence of the basins themselves seems never to have occurred to him, although all the Himalayan rivers are rock-borne torrents in the region of the missing lakes.*

As more directly bearing upon the point before us, it would seem that, in the absence of such conspicuous evidence as the marine boulder-drift of Europe, separating the ossiferous valley-deposits from all the tertiary formations, Falconer failed to observe the very marked stratigraphical features that do occur. He speaks of there being no break visible in the tranquil succession of deposits; that "the present physical order of things, modified only by alterations of level, by upheavement and depression, could be traced back in an unbroken chain to the ossiferous strata of the valley of the Narbadá and of the Sivalik hills" (op. cit., Vol. II, p. 576, and Quar. Jour. Geol. Soc., London, Vol. XXI, 1865, p. 386) ; he constantly speaks of the Sivalik hills as "an upheaved portion of the plains of India." All this is exceedingly inaccurate and misleading. I have added many proofs to at least one point of Falconer's description, that of the distinct connection of the Sivalik deposits with the present local mountain-features; but the most cursory examination reveals to the geologist great gaps in the series of deposits. At Hardwar, a place well known to Falconer, the old alluvial clay of the plains is found resting upon a deeply denuded surface of vertical topmost Sivalik strata. The relation is stratigraphically similar, and probably nearly historically corresponding, to that of Loess of the Rhine to the Molasse of Switzerland. There is full evidence, too, that the glacial period was sensibly felt in these regions: in the Kangra valley, where a range of considerable elevation (the Dhaoladhar) occurs close to the edge of the low hills, I found unquestionable glacial erratics scattered over a surface of the Sivalik formations, at a present elevation of 3,000 feet above the sea (Mem. Geol. Sur., India, Vol. III, p. 155). I do not doubt that if we could fetch up a meridional slice of the Gangetic plains, we should find deposits representing the whole interval indicated; and it is not improbable that the series may yet be picked out from outcrops in different parts of India. What I want to show is that the two terms of the series we now have hold of—the old Gangetic alluvium and the Sivaliks—are very wide apart; and so, that the Sivaliks being older pliocene or upper miocene, the other may be ever so recent.

If we make any attempt to gauge the age of the old alluvium from the other side, we are led pretty much to the same result. All purely geological computations are estimates of work done; and we have the immense advantage of knowing that the operatives never idle, or never even take rest. The final appeal for the antiquity of the human remains in the valley-gravels and cave-deposits of Europe is not to the little-known laws and conditions regulating the extinction of species, but to the mechanical work done in altering the features of the country, in excavating wide valleys, or in laying out broad plains subsequent to the date of those remains. It is quite true that the result here, too, is only an approximation within wide limits; that the independent variables of the problem,

* It puzzled me to think upon whose observation Sir Charles Lyell could have adopted such a view as this, as stated in his "Antiquity of Man" (p. 319). The puzzle is now cleared up. If Sir Charles, as Falconer supposed, annexed information without acknowledgment, he did not always gain by the transaction.

while largely affecting the result, can only be indirectly conjectured. For instance, a change of levels would greatly affect the eroding and depositing power of rivers; or a change of climate and of rainfall, with perhaps the addition of severe frost, would have a like disturbing effect upon the work done, without our being able to assign the amount of those by-gone conditions. But taken all in all, reliable indications, and comparative, if not actual, measurement can be made.

The Narbadá valley, meaning that broad area of the river's course from where it leaves its gorge in the trappean plateau of Mandla near Jabalpúr, to where it enters its narrow gorge through the Vindhyan quartzites below Hosungabád, is about as unfavorable a case as one could select to exhibit symptoms of change. It is a rock-basin, a valley excavated chiefly, if not entirely, in crystalline and slaty metamorphic rocks, between two plateaus of little-disturbed sandstone-formations, the Vindhyan on the north and the Máhádévá on the south, and converted into a rock-basin by some oscillation of level. It would seem that the change was not rapid enough to produce a lake, for in all the sections now exposed coarse gravels occur. As soon as this basin had received the charge of deposits due to this change of level, and supposing no further earth-movement to occur, the change of features to what we now find would depend upon the eroding power of the river to lower the rim of the rock-basin, and thus gradually to bring under denudation the deposits it had so lately laid down. If then we could fix the maximum thickness attained by the deposits, and also the rate at which the river can lower its gorge of discharge, we could assign something like actual dates for the successive phases both of denudation and of deposition, on this supposition of normal conditions, without interference of crust movements or other occasional forces. The process is now going on. The river at least cuts faster than pluvial denudation can work in lowering the general surface, for its bed is now some 80 to 100 feet below the level of the adjoining plains. There is nothing to suggest that the depth of the valley-deposits ever much exceeded what we now find. The plains deposits never extended into the valleys of the Sátpúrá, some of the minor streams from which are still accumulating materials upon the deposits of the main valley. There are nowhere any signs of high-level deposits, along the borders of the basin, whether remnants of a former phase of denudation of the actual valley-formation, or (like the ossiferous gravels of Northern Europe) remnants of deposits formed in a more ancient shallower rock-valley. The ossiferous beds of the Narbadá seem to be simply a member of the last and only valley-deposits, which have now for a long period been undergoing denudation. But I know of nothing to suggest that the change from deposition to erosion supervened at a time much prior to the 'recent' of the geological scale.

The only debateable stratigraphical point upon which a stand might be made, is whether unconformity occurs, indicating a general and possibly a great interruption of deposition between the ossiferous beds exposed at or near the present level of the river channels and those above them. I have examined many sections with a view to testing this supposition, but I have failed to confirm it. One often finds local unconformity—coarse gravel upon a weathered surface of stiff clay; but these are no more than must occur in the normal process of formation of river deposits; and most frequently it is impossible to detect any break in the section. The fossils, moreover, occur largely in the gravels above this supposed unconformity, without any sufficient grounds for supposing them to have been washed out of the clays. Thus, then, there is nothing like a corresponding amount of evidence for work done here since the age of these bones, as there is in Europe for work done since the formation of the ossiferous gravels and cave-deposits; although the permanent staff of operatives is much more powerful in the former case. Every season there occurs in the Narbadá a rise of from 40 to 70 feet, with a stream of great force. It is, as I have said, impossible to make an exact comparison, on account of the undetected influences that

may have been at work on either side to accelerate or to retard. I only wish to point out that there is no presumption, either palæontological or mechanical, that these Narbadá deposits are older than the late Pleistocene.

If we turn to the great Gangetic valley, the old alluvium of which Falconer ranked with the Narbadá beds, the physical arguments lead us to a like conclusion. Here we have not to deal with a rock-basin; and the conditions are more appreciable. In the upper part of its course the Ganges cuts a broad abrupt valley, 60 to 100 feet below the level of the adjoining plains. In the lower region of the plains the denudation has taken a wider sweep; the old alluvium has for the most part been removed, isolated remnants of it only being found; and those, at least towards the modern delta, are being enveloped in the encroaching deposit of its alluvium. On the whole, the features of denudation in the Ganges valley seem to imply that this action was brought about by the subsidence of a former delta of greater extent than the present one, not by an elevation of the mountain region. Along the upper edge of the plains, the minor mountain-streams are still massing deposits continuously over the old alluvium; and in some of these recent torrential accumulations a fossil Hindú village has been dug out. If we now turn to our comparisons, it is evident that the signs of change and of work done here are nothing like so great as that recorded of the Rhine and the Danube in their valleys within post glacial times. Or absolutely, even stretching to the utmost the legitimate assumption of comparative stability of conditions in India, we can hardly reduce our estimate of the necessary duty of such a river as the Ganges, during the period allowed by a minimum computation for the lapse of time since the glacial period of Europe, to the amount of work I have indicated. So that here again the opinion obtrudes itself, that these old ossiferous alluvial deposits are not more ancient than the late Pleistocene.

From the description given of the implement-bearing lateritic gravels of Southern India by my colleague Mr. R. Bruce Foote (Quar. Jour., Geol. Soc., London, Vol. XXIV, p. 484, 1868, and Mem. Geol. Surv., India, Vol. X, 1872), I should think they may be as old as the Narbadá gravels.

H. B. MEDLICOTT.

July, 1873.

The shells of the ossiferous deposits.—The shells Mr. Hacket has placed in my hands for determination are all of them species, known to occur in the ossiferous gravels of the Narbadá, a list of which is contained in the Memoirs of the Geological Survey of India, Vol. II, page 284. They are all of them in the mineral condition observable in the shells from these ossiferous beds, and some of them are embedded in the ordinary matrix of many of the fossils of the group, a gravel strongly cemented by lime.

The most numerous and characteristic shells are Uniones, of precisely the same species and varieties as those now living on the spot, and it may be incidentally added, that no molluscous species is known to be included in these ossiferous beds which is not now living in the valley, though many species now living, have not as yet been detected in the gravels, which is a fact not without interest when the revolution is considered which has been wrought among the vertebrata since the days of the Hexaprotodon and Tetraprotodon, which, with numerous other pachyderms, proboscidians, and ruminants, then roamed over Central India, and disputed with man for mastery in the primeval world.

Associated with the Uniones, occur also Bulimus pullus, Gray; Melania tuberculata, Müll.; Planorbis convexiusculus, B.; Lymnæa acuminata, Lam. (?); and a Corbicula, probably Corbicula Cor, Sow.

Three species of Unio occur in the collection, U. MARGINALIS, LAM.; U. CÆRULEUS, LEA; and U. CORRUGATUS, MULL., which last embraces four distinct races, usually classed as species by most authors, but which, after some study of the Indian forms of the group, I incline rather to treat as local and permanent races, thereby reducing within manageable and natural limits the crowd of shadowy species, with which the literature of the group is burdened.

U. MARGINALIS, *Lam.*

This species is not uncommon, but is not so finely developed in proportion, in the ossiferous gravels, as the others, neither does it seem to occur quite so well preserved, nor to obtain the same weight of valves as in the other species, in which respect it simply agrees with the same species now living, which never displays any considerable thickening or calcification, under any conditions, however favorable. A perfect example, not fully grown, measures—

Breadth	57	Mills.
* Length	29	
Thickness	19	

Allowing for slightly broken edges in the fossil, these proportions closely accord with the living shell which I give from Manbhoom—

Breadth	61	Mills.
Length	31	
Thickness	18	

A second specimen from these beds, which may be considered fully adult, measures 93 mills by 43.

U. CÆRULEUS, *Lea.*

This species attains to a superb development in the ossiferous gravels, and merits nominal recognition, since it does not quite correspond with any variety hitherto separated. It may stand as var. Namadicus, Theob.

Two perfect examples measure respectively—

	a.	*b.*	
Breadth	56	46	Mills.
Length	31	24	
Thickness	23	17	

A precisely similar form is now living in the Narbadá, and differs less, from the type of the species, than some other races in other parts of India do. It agrees generally in the form of the teeth, in shape, color, and sculpture, save that each character is heightened in the Narbadá form. The lateral teeth often display a carneous tinge, and the sculpture of the valves is not only stronger than in the type, but covers a far greater area, both on the valves and their posterior slope. A very similar form, though departing more from the type as regards shape, inhabits the Kistná valley, where it attains a breadth of 60 mills—(the type measuring only 43).

U. CORRUGATUS, *Müll.*

It is a great pity that the type of that species of Unio, which seems to unite the greatest number of races in India, should be so ill characterised, difficult of identification, and apparently, with a good series under view, so aberrant from the more strongly marked forms, which strict zoological argument requires should be united to it. On this subject I would

* Length is measured at right angles to a line tangential to the ventral margin.

refer to Mr. Blanford's contributions to Indian Malacology in the Journal As. Soc., Bengal, for 1866, page 134, which contain a highly useful and condensed paradigm of our Indian Uniones.

Mr. Blanford is undoubtedly correct in saying that "both Lamarck's and Chemnitz's types (of Corrugatus) are quite distinct from Benson's U. favidens, which has been confounded with them," but with a very large series before me, I consider that this distinction is a *racial* one, not a *specific* one.

If the rules of priority would have permitted it, I should have preferred, as the more natural course, to have taken Benson's U. favidens as the type of that species round which so many races or sub-species cluster; but as this cannot be, U. favidens must stand as a race perfectly separable, but still only a race of the wretched, ill-nourished U. corrugatus, Müll., for the epithet "*tenera*" applied to any of the forms of this robust species, stamps it as an abnormal individual, impoverished by unfavorable local conditions, and subjected to deficient or imperfect alimentation.

That the utmost diversity exists between the races which I unite under U. corrugatus may well be, since without pretending to anything like a complete knowledge of all the forms of this species throughout its entire Indian range, there must still be admitted sixteen separable races, exhibiting very variable degrees of difference from each other; even after excluding *U. lævirostris* of Benson as a synonym of *U. Nagporensis*, Lea, and uniting *Nagporensis*, Lea, with Wynegungensis, Lea, with which it is essentially identical, or too trivially distinct to be separated, judging from a large series of both forms.

U. CORRUGATUS, *Müll.*

1. Var. triembolus, B.

This form occurs very fine, both living and fossil, in the Narbadá.

A fossil specimen measures—

Breadth	66	Mills.
Length	40	
Thickness	26	

and I have no living specimen which quite attains these dimensions.

2. Var. Wynegungensis, Lea.

A stout trigonal and elongate form, which approaches the *U. lævirostris, B.*, seems equally common with the last, and passes into it.

A fossil specimen measures—

Breadth	73	Mills.
Length	39	
Thickness	27	

And in this case also I have no living specimen which equals these dimensions, my largest specimen of this type from the Kistná only reaching 60 mills.

3. Var. Indica, Sow.

This well marked form occurs both living and fossil; one of the last collected by Mr. Hacket measuring—

Breadth	30	Mills.
Length	27	
Thickness	19	

This is not a large race, as a fine recent specimen from the Narbadá only measures 41, 34, 21 mills. It is mainly confined to the Narbadá, though I have it also recorded from Rajpútana.

4. Corrugatus, Müll.

The preceding forms pass into one, which in the young state closely approaches the type, save that it is a stouter shell.

There is, moreover, no fixity as regards the sculpture on the valves, so far as the extent covered by it, still the general facies is that of the type, which, according to Mr. Blanford, would seem more common in Southern India than in the Gangetic* basin. A fossil specimen measured—

Breadth	...	...	...	27	Mills.
Length	...	...	...	20	
Thickness	...	...	...	12	

July, 1873. W. THEOBALD.

NOTE ON THE BARÁKARS (COAL-MEASURES) IN THE BEDDADANOLE FIELD, GODÁVARÍ DISTRICT, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

The question as to the existence of coal in the Godávarí District, and indeed in the Madras Presidency—for the area under consideration is the only known one of coal-bearing rocks in the British territory to the south of the Godávarí river—is still as full of obscurity as it was when I drew attention to the Beddadanole field last year. I have had, during this season, another opportunity of examining the ground most closely, but without success; and this search was so close that it does not seem possible that any outcrop of coal will ever be found by surface searching. Any further exploration must, therefore, be made by boring, and I am not without hope that coal may then be found.

2. The most important point, and in fact the only tangible one to be relied on, is that the rocks of the Beddadanole area are *Barákars;* that is, they belong to the lower member of the DAMÚDÁ SERIES, or the coal-bearing rocks of India. It is true that no seam of coal is visible, but this does not at all necessarily imply the non-existence of coal.

3. To try and show that coal may exist in this field, I shall compare it with other adjacent fields, *viz.*, that to the north-west, on the Godávarí below Badrachellum; and the Singareny coal-field to the westward, in the Nizam's dominions. In the first of these, though it was reported by Colonel Haig to Mr. W. T. Blanford that coal was said to have been found down there, no coal was to be found at the place; indeed, the borings afterwards put down would seem to show that coal could not occur at the surface. At any rate, the rocks were seen to be DAMÚDÁS; and borings revealed seams of coal. These are, however, not of much extent on the British side of the river, though they are probably large enough on the Nizam's side, as I have since found that an outcrop of possibly the same beds shows at some twenty-five miles to the south-west.

4. As regards the Singareny coal-field, I can compare it more closely with that of Beddadanole, having likewise again visited it this season, when it is now being thoroughly examined by Mr. Heenan, the Superintendent in charge of the Nizam's coal-fields. The only difference of outward circumstances, as regards the present enquiry, between this and the Beddadanole field is, that coal did show at the surface in the former, though only in the most fortuitous way. Otherwise, the series of rocks (*Barákars*) in each field are identical

* For the information of Naturalists at home, I may as well add that the Narbadá does not belong to the Gangetic basin.

in every way, in their appearance, constitution, and mode of occurrence. There are plenty of outcrops of rock over this Singareny area where one might expect that seams of coal, if they existed, might appear at the surface; but such is not the case; there is only the one large "pot-hole" hollowed out in the low ridge of sandstones in the bed of the river with the seam of coal showing at the bottom. Nevertheless, since the borings have been put down by Mr. Heenan, not only has the first found seam been traced in other parts of the area, but three more have been struck, one above my seam and the others below. So that here we have a field with at least four seams of coal, the lowest found as yet being a very thick one, and having its strata so laid down that all these seams ought to crop out at the surface, whereas only one is just exposed. Outcrops of all the seams do probably exist; but, as would be likely, owing to the coal being cut into and washed out at these places by the weather and the streams, they are either now covered up by sand and débris gathered between the exposures of the harder beds, or are hidden by the settling down of superincumbent strata.

5. This concealment, or washing out of coal outcrops, may equally exist in the Beddadanole field, as, it is hardly necessary to state, there are numerous spaces in the nullahs between the exposed rock masses which are filled in with sand, though, as a general rule, the sandstones are very well and frequently exposed. Again, the lie or dip of the strata is very low, on the average about 5° to the westward, and they undulate to some extent; while the general surface of the area occupied by the *Barákars* is flat; and thus the sandstones have not been deeply cut into by the streams, so as to show enough of the strata.

6. There is, besides, a physical feature of this area which seems to hold out some hope that there may be hidden coal. The field is traversed by a river of from 50 to 60 feet in width, which flows in the direction of, or with the strike of the strata, or along the outcrop, that is, nearly north and south, a course which, viewed with the rest of its route over the *Kámthi* area, is somewhat exceptional. This course of the river may be due in part to the existence of a band of softer strata occurring between the sandstones which show at rare intervals on either side of the river. Indeed, I think there can be no doubt that there is a band or seam of softer or more easily worn strata covered up by the sandy bed of the river; or we should have had rock cropping up at places in the channel. But boring alone will tell whether coal seams occur in this soft and denuded bed.

7. The exposed area of *Barákars* is, unfortunately, not extensive, being only about $5\frac{1}{2}$ square miles. It is covered up immediately on the western side of the field by the great series (*Kámthis*, of Blanford) of red and brown sandstones, in which there is no coal, constituting the upland country of Asharaopettah (Nizam's dominions) and Jeelagoomilly, &c., (British territory) to the westward. There must, however, be a good spread, equal in area at least to that exposed, of the *Barákars* hading down underneath the *Kámthis*. I am led to expect that this *infra* Kámthi extension is larger than I originally thought, on account of the westerly dip and the great thickness (about 300 feet at least) immediately under the covering edge of the *Kámthis*. Also, as we may judge to some extent by the lie of these last towards Jeelagoomilly, there is a roll up again of the beds towards that village, thus forming a synclinal or depressed curve of the strata, indicative of an ancient valley, over part of which the Beddadanole *Barákars* were deposited. This same valley beneath the *Kámthis* appears to have opened out south-eastwards, leading to the inference that if the *Barákars* do extend any distance underneath, they would lie down this valley, rather than up or across it, and so be still in the British territory.

8. An indication of the possibly large extension of the *Barákars* underneath the *Kámthis* is shown some miles to the north-west; for, as already stated, I have lately found what certainly appear to be *Barákars* cropping out on the western edge of the great

Ellore-to-Badrachellum spread of *Kámthis* at a point some twenty-five miles south-west of the coal-field below Badrachellum, and which may be an extension of that field.

9. To summarise, I think it may be concluded—

1*st.*—That there is a likelihood of coal from the fact that the sandstones of Beddadanole are of the *Barákar* group.

2*nd.*—That there is some slight reason for suspecting that the Beddadanole river bed conceals coal outcrops.

3*rd.*—There is every expectation of the area, exposed and hidden, of the *Barákars* being at least ten square miles in extent, if not a great deal more, and that it lies in the British territory.

So that, should it be decided to try the field by boring, and I would most earnestly recommend this proceeding on account of the above three conclusions, though they be laden with conjecture, the crucial bore holes ought to be put down near the right or western bank of the stream, where they will run to a depth of over 200 feet before the coal-bearing strata are pierced. One bore-hole at about half-way down the course of the river within the field would be almost sure to strike coal if there be any in the field; though, even if this failed, another might be struck down about three-quarters of a mile further west, as the first bore-hole would only have pierced about half the thickness of the exposed field.

Details as to the character of the rocks, their lie, and the size and position of the field have been already given in the Records of the Geological Survey of India, Vol. V, part 4, 1872.

CAMP, GODÁVARÍ DISTRICT,
April 18*th*, 1873.

WILLIAM KING.

NOTES FROM A PROGRESS REPORT ON THE GEOLOGY OF PARTS OF THE UPPER PUNJAB, *by* A. B. WYNNE, F. G. S., *Geological Survey of India.*

The first two seasons during which the operations of the Geological Survey were extended to the Punjab having been devoted to the examination of the Salt-Range, the following one was, by order, chiefly spent in rapidly reconnoitering the country surrounding the upper plains of the Punjab, both on this side and, as far as possible, trans-Indus, in order to obtain a preliminary general knowledge of the complex geological features presented.

At its close lines of observation were carried through the Hazara district, and a closer examination was made of the Sir Ban mountain region, close to Abbottabád, which was found to afford an epitome of much of the geology of the Upper Punjab (see Memoirs Geological Survey, Vol. IX, Art. 3.)

At the commencement of the succeeding season, that of 1872-73, the detailed working of the one-inch maps of the Rawul Pindi district was taken up and carried on with one interruption, during which the Salt-Range was again visited, in order to obtain a special collection of its mineral products for the Vienna Exhibition of 1873.

With the valuable assistance of Dr. Warth, Deputy Collector at the Mayo Mines near Pind Dadun Khan, a series of specimens of several maunds in weight was formed and despatched to Calcutta. This included a block of rock-salt cut purposely from the mine, about two tons in weight; and amongst the others, a complete series of large specimens illustrating the geological structure of the part of the range overlooking Pind Dadun Khan, ; besides

several specimens of newly found minerals from the Mayo Mines, such as Glauberite and Kieserite, varieties of pure potash salts, and others in combination with sulphates.

Specimens of the cubical salt of Kalabagh, the alum shale, gypsum containing quartz-crystals, and gold sand from this latter locality, were also added to the collection with the help of Mr. Wright, Collector of the Salt Revenue, and Dr. Warth.

At the same time efforts were made to obtain a block of trans-Indus salt from the mines of Bahadur Khel, which resulted in the addition of a 27-maund block of this salt to the collection forwarded by Captain Plowden, Assistant Commissioner at Kohat.

These two large specimens show the marked difference of colour between the clear white or reddish salt of the Salt-Range and the gray or dark-coloured trans-Indus salt.

It was during the progress of the Vienna collection at the Mayo Mines that the discovery of the potash salts was made, attention being called to their situation in the mines by the hardness of part of a band of 'Kullur' or impure salt through which a drift was being excavated. On examination of this, the band of potash salts was found to be 6 feet thick, partly pure and partly mixed (sulphates, &c.); but its further extension could not be at the time ascertained owing to its situation, while there was little or nothing in the general appearance of the potash mineral to distinguish it from the ordinary salt. Specimens were immediately subjected to a preliminary analysis by Dr. Warth, but the crystallography of the new found salts was a subject unapproachable for want of proper instruments for measurement. It is hoped that some of the perishable crystals put up in glass bottles may have reached Vienna in a state fit for examination.

The deposit will probably prove interesting, as the only one known within British possessions, and may become very valuable should the importation of these high priced salts into England from the Continent be interrupted. Dr. Warth suggests that it may eventually be found advantageous to work this deposit for the alum factories at Kalabagh. For shipment from India the transport of the salts would present no great difficulty by the wire-tramway from the mines to the banks of the Jhelam, and thence by water to Kotlee on the lower Indus or to Kurrachee.

In carrying out the detailed examination of the Rawul Pindi district eastward of that station, the hills were found to exhibit the relations of the "sandstone and clay" portion of the great outer tertiary belt, well known as the southern border formation of the geological system of the Himalayas. Here the lower, red, or Murree (or Subathu), beds pass upwards by alternations of red clays or shales and gray sandstones (locally distinguished by the Punjab survey-party as the "red and gray" series) into softer gray sandstones with clays of a more orange colour, the highest beds being a thick group of incoherent conglomerate rocks, previously known to exist on the Indus and at both ends of the Salt-Range proper, as well as in some other places. In the generality of cases this conglomerate group was found to present a gentle transition from the lower beds upwards; the pebbles, chiefly of crystalline rocks, after their first appearance increasing in number and size till the whole rock becomes a mass of small boulders or large pebbles slightly held together by an inconsiderable calcareous matrix. The rock is seldom found hard enough to show its own outcrop, and presents the greatest difficulty in discovering clear sections, though hills formed of it possess in their undulating pebbly surfaces a characteristic by which the conglomerate can be recognised from long distances.

Associated with this conglomerate group, and indeed throughout the whole of the arenaceous and argillaceous portion of the tertiary rocks of this country, are various beds, usually calcareous sandstone, conglomeratic sandstone, or a peculiar finely concretionary calcareous and earthy or sandy rock of a gravelly pseudo-conglomeratic appearance, often containing

more or less numerously fragments of bones. In the upper and more conglomeratic portions of the series, these bones are frequently mammalian; while below, even to the base, and there associated with Nummulitic, or *Rotalina*-bearing, layers, the bones, rarely in a good state of preservation, are believed to be more commonly reptilian, as appears from Major Vicary's writings to be the case in the corresponding beds at Subathu.*

From Murree† southwards the general stratigraphical structure of the hill country is a succession of great waves commencing with an anticlinal curvature close to that station, the synclinals of the curves embracing some of the higher strata, form grand vertical cliffs, when largely composed of massive sandstones bedded nearly horizontally, as around the elevations of Karor and Nurr'h, very similar to the cliffs on the Indus at Dangote above Kalabagh.

Towards Jhelam the curves appear to become softer and more open, and some of the highest beds, the conglomerates previously mentioned, come in.

In the vicinity of Murree, and along deeply excavated valleys lying in a general direction north of east and south of west, overlooked by the northern slopes of the Murree ridge, the lower red tertiary rocks terminate; one side of these valleys being chiefly formed of the red rocks, and the other of contorted limestones and shales, towards which the Murree beds are frequently inclined. These are the main or striking circumstances of the positions of the rocks, which, however, when examined in more detail, are not found to be strictly limited to opposite sides of the valleys, small portions of the red beds being found in the limestone hill slopes, and a pretty constant rib of nummulitic limestone stretching from the Kooldunna hole (lying northwards from Murree) along the foot of the Murree ridge westwards by south.

The rocks on both sides of the junction-valley present the strongest evidence of disturbance; and faults, or lines of displacement, are numerous. Starting from Murree, red and grayish sandstones, with imperfect plant-impressions alternating with deep red clays, form all the slopes in a descending northerly direction, till the rib of limestone is reached. On both sides of this, calcareous nummulitic layers alternate with the red beds. And gypsum occurs more or less on the Murree side of the rib and close to it. Beyond the rib of strong dark limestone, red and gray sandstone and clay beds (forming the major portion of Kooldunna hill) predominate; and on the ascent of the opposite slopes of the Mochpoora chain, gray nummulitic limestone, sometimes crowded with small *Rotalinæ,* alternate with dark shales. But even here detached longitudinal masses of the red Murree beds lying parallel with the principal features appear to be faulted deeply into the limestone group. Further up on the Mochpoora ridge and beyond it, northwards, jurassic and triassic rocks appear, in the manner shown in Dr. Waagen's paper on the neighbourhood of Khairagully and Chumba Peak (the result of a joint examination of the locality with the writer, see Records Geological Survey, Vol. V, page 15).

In studying the junction of the more mechanically formed tertiary beds with those consisting largely of nummulitic limestone along the Murree valleys but little value can be attached to the distorted dips of the beds; some traces of a former regular succession from the limestones of the Mochpoora ridge upwards into the Murree beds being perhaps slightly indicated; and the present positions of the rocks may be, for all that is seen to the contrary, freely and fairly attributed to the united results of folding and faulting; traces of the latter being too prevalent for faulted displacement to be excluded from consideration in the effort to account for the existing state of things.

Beyond the Murree region westward, the junction of the Murree rocks with the limestones to the north presents very much the same general character, the gypseous zone being

* Quar. Jour. Geol. Soc., London, Vol. IX, p. 72, 1853.

† Koh Mari (*i. e.*, Mari mountain) is the name of this locality, the a having the sound of ŭ; hence the adoption here of the common phonetic and more popular spelling.

traceable at intervals in the position first described. The outer limestone rib expands and is flanked by another similar band, the alternation of limestones and Murree bed being apparently produced by faults; at least it has entirely this aspect in the neighbourhood of Shah Durah.

Further west a strongly marked line, also bearing the strongest resemblance to a fault, diverges north of Rawul Pindi from the main line of junction in the direction of the Margulla pass, on the Peshawur road. Along it the Murree beds are brought against the hill limestones, here including both nummulitic and jurassic rocks (with perhaps an intervening cretaceous band). The jurassic beds contain a very marked layer made up of large *Trigoniæ* resembling *Trigonia Ventricosa*, Kraus, with some smaller forms; while beyond Margulla *Ammonites* and *Belemnites* are also to be found. As usual along the contact of the limestones and finely detrital rocks, the red Murree beds are often either vertical or highly inclined towards the limestones. The actual junction surface, from being situated at the foot of the hills, is concealed; and the branch line disappears beyond Margulla, the low ground in that direction being heavily covered with detrital deposits, and the small hills in which the spur from Mochpoora terminates being formed of the nummulitic and jurassic limestones, shales, &c.

The main line of boundary between the limestones and the Murree group continues from the place of divergence north of Rawul Pindi westwards, marked at first by low limestone hills at the foot of the Mochpoora ridge or spur, which gradually increase in height and width, till they form the chain of the Chita Pahar mountains, abutting on the Indus several miles southward of Attock, near Nilab Gâsh. Beyond this the same feature continues westward along the Affreedi hills passing just north of Kohat; on this line also the gypseous zone seen at Murree and more largely developed at Tret, as well as lower down in the plains, may be recognised at intervals. In connexion with this gypseous zone, and sometimes in the gypsum itself, are sulphurous springs, which bring petroleum or mineral oil to the surface; this also frequently occurs slightly impregnating the adjacent limestones.

Along the whole of this line of junction within British territory, from near the Jhelam* to the Indus and beyond it, *the positions* of the two sets of rocks furnish nothing decisive in the way of evidence to prove which is the older: and in many places the inference from dips would be directly contrary to fact. The nummulitic limestones of the hills being, however, found in some spots close to the boundary passing downwards into jurassic rocks (with or without a thin intervening band which may be, but is not here proved cretaceous), all doubt of the true position of the red rocks is removed; and their close association with certain layers containing nummulites on the south side of the junction fixes their age with certainty.

It will then appear that on one side of the general boundary there are red Murree beds containing layers of nummulitic, calcareous, or earthy rock, while on the other there is a mass of limestones and shales of nummulitic, jurassic, and perhaps some of cretaceous age. The junction itself presents all the features of a fault or band of several faults, and the only reason why it should not be unreservedly accepted as such is that, in the Simla Outer-Himalaya examined by Mr. Medlicott, the same tertiary sandstones and clays as occur in this country have been divided by that gentleman into groups, the boundaries of which, having the same general resemblance to lines of fault, are in most cases believed and in some are proved by him to be lines of unconformable contact and not of faulting (see Memoirs, Geological Survey, Vol. III).

* The continuation of this line in the valley of the Jhelam has been recently seen. It makes a sharp bend northwards near Kohala, and runs along the foot of the Mochpoora and Huzar hills on the right bank of that river, crossing the bend of the stream near Mozufferabad in Cashmere. Here it bends to south-east, following the course of the Jhelam still on the right bank, but far up on the flanks of the Kyj Nag range to Ooree, where it crosses the river and takes a course along the outer flank of the Peer Punjal chain. Slates, metamorphic rocks, and occasionally limestones, are seen in junction with the red Murree rocks, the line still resembling one of faulting.

There can be little or no doubt that the red Murree rocks are, or represent, the nummulitic Subathu beds of Mr. Medlicott, which, in the Simla districts, rest unconformably upon limestones and slates of unknown age; while in this part of the Punjab nummulitic rocks occur on both sides of the junction. It would be manifestly improper to ignore this line of junction and carry the nummulitic boundary across it while it presents so marked a feature. Without some palpable local evidence, it would be equally improper to indicate an unconformable break in the nummulitic series; but as this might possibly exist together with the faulting and displacement which seems to have occurred, it is proposed to express the line upon the map as one of fault, at least provisionally or until the whole country has been explored, with the hope that something further may be found to explain the difference between the present aspect of the junctions here and in the Simla regions.

With respect to the other junctions of Mr. Medlicott, showing repeated unconformity in the ascending series between his tertiary sub-groups, the difference in this district has to be noticed. The description of the rocks would point to their close identity; but in the Simla region the succession appears to have been interrupted; while here the most apparently regular sequence and conformity has only been observed southward from the limestone hills, crossing the country in an east and west direction north of Rawul Pindi; the red Murree rocks, either vertical or dipping at high angles, reach down to the latitude of that place, interrupted only by a long ridge of nummulitic limestone of the hill type, which, lying west by south from the station, appears to occupy a space between two converging lines of fault. Southward of this the Murree beds pass up (still retaining their high dip) into the 'red and gray' series in which the first bands of conglomerate appear. In these conglomerates, notwithstanding the parallelism of the beds, are enclosed limestone pebbles, proved by the small *Nummulites* which they contain to have belonged to that formation; but where the break occurs during which the denudation of the older rock took place it is at present impossible to say.

Above the 'red and gray' rocks come others with more of orange colour in the clays; and these pass up, as already stated, into the conglomerate group. The upper portion of the series in the neighbourhood of these comglomerates has been identified from its fossil bones with the Sivalik group by the late Dr. Falconer (paper by Mr. Theobald on the Salt-Range: Proceedings, Asiatic Society, Vol. XXIII, 1854, page 677). So that in this district the Subathu and Sivalik groups of the Simla region may be considered present; while many of the intervening rocks would answer to the description of the Nahun beds of Mr. Medlicott. The peculiarity of the frequently interrupted succession in that region, contrasted with that almost complete sequence here, would indicate considerable difference in the physical causes which affected the deposition of the tertiary rocks in one region as compared with the other.

It is difficult to estimate the thickness of these sandy and earthy tertiary rocks in consequence of the numerous contortions, and the all but positive certainty that in many places, where the beds are apparently steady at high angles or vertical, the arches of numerous folds are concealed. The fact of this contortion impressed Mr. Lyman (Report on the oil regions of the Punjab) with the idea that the thickness of the whole was much less than it would appear. But while it is of course possible, it is at the same time not easy to imagine, all these contortions lying exactly so that the plane (or approximation thereto) of the surface of the country should intersect them without exposing either recognisable repetitions of each group or some of the next underlying strata. The absence of these cases seemed to point to an enormous accumulation of the beds, notwithstanding their convolution; and this is rendered more probable from an observation lately made in the Jhelam valley within Cashmere territory, where part of the red Murree group, dipping regularly at

an angle of 45°, was estimated to have a thickness, on the flanks of the Kyj Nag range, of about one and a half miles. The dip in this case also was (obliquely) towards the adjacent older rocks.

Besides the tertiary conglomerates previously described, there is another very extensive group of more recent age, the pebbles in which are largely composed of limestone; it is very well developed about Rawul Pindi, and spreads unconformably over great tracts of the country, alternating with drab or pale pink or red or purple brick-clays, and frequently associated with calcareous tufa or calcareous conglomeratic solid massive beds called by the natives '*Koonjoor.*' The basal part of this group in immediate contact with the tertiary sandstones is often formed of strong beds of calcareous tufa or travertin.

These conglomerate and clay rocks are at present considered lacustrine, or formed by wandering river action; and their boundaries, if shown upon the maps, will be extremely intricate, as they are often cut through by the nullahs exposing the rocks beneath.

The superficial covering of the country is largely derived from the clays of this group; and where clays, shales, and such soft rocks abound, there is no lack of material to form a frequently thick deposit, the result of atmospheric action.

SRINUGGUR, Cashmere, *May 25th*, 1873. — A. B. WYNNE.

COAL IN INDIA, BY THEO. W. H. HUGHES, C. E., F. G. S., *Associate, Royal School of Mines.*

I trust it will not be uninteresting to the readers of the Records of the Geological Survey to have placed before them a few brief remarks which will tend to widen the scope of their knowledge with respect to our Indian coal-fields, and enable them, when the subject of coal is discussed, to uphold the claim which India enjoys to rank amongst the great coal-bearing areas of the world. It will doubtless surprise many to learn that both in the superficial extent of its coal measures and associated rocks, and in the actual amount of its coal, India is surpassed by few countries; and that with respect to the size of some of its seams it stands pre-eminent in the literature of mining.

Even that land of monstrosities and natural wonders, the United States of America, can exhibit nothing to compare with the gigantic seams of the Hengír and Damúdá coal-fields, some of which are one hundred and sixty, one hundred and twenty, and a hundred feet thick. These figures of course do not imply that there is this amount of pure coal; the term seam is used in its technical sense, as embracing the whole sum of coal and partings in a given bed.

Until within the last few years the information regarding our coal-fields was scanty and imperfect; but of late, the action of Government and the labours of the Geological Survey have been more in accord with the requirements of the country; and the result is that, although our data are still far from being complete, yet we can form an approximate estimate (which may be accepted as a nucleus for future computations) of the area of our probable coal supplies, their geographical position, and the quality of fuel which they can yield.

And in the first place with regard to our probable coal supplies, it becomes more and more important, in the face of the steadily increasing price of English coal, to enquire whether India will be able to furnish the fuel so essential to the further development of those industries which the energies of Englishmen have in some instances created and in other cases fostered to a maturer growth. In answer to this question, around which centres the chief interest in this article, I think it will be sufficient if the reader glance at the subjoined table of areas to feel satisfied on this point.

The same method of calculation has been acted upon in regard to India, in the determination of the superficial extent of its coal-bearing areas as that applied to other countries, and the length and breadth of the tracts over which coal rocks *may be presumed* to extend have been multiplied to give the number of square miles.

Taking the coal-fields already partially and in whole examined, and allowing for the unsurveyed portions of Central India, Assam, Burmah, and the Tenasserim province, &c., we may safely assume 35,000 square miles as being within the mark.

In order to show how these figures are arrived at, I append the following table. Besides, however, enumerating the different Indian areas, I have added a list of such countries the areas of which I have been able to compile from various sources of reference; and I have also noted the countries in which coal is known to occur, but concerning which there is no knowledge of the extent of their coal measures. By thus enlargening the table, I hope its usefulness for the purpose of comparison will be increased:—

Table of Areas.

Name of country.	Area in square miles over which coal-rocks may be presumed to extend.	REMARKS.
India	35,000	*This mileage is made up as follows:—* Godávarí area (including its affluents) ... ... 11,000 Son ... ... 8,000 Sirgújáh and Gangpúr area ... ... 4,500 Assam ... ... 3,000 Narbadá area (including its affluents) ... ... 3,500 Damúdá ... ... 2,000 Rájmahál area ... ... 300 Unsurveyed and uncomputed areas ... ... 2,700 Square miles ... 35,000
United States	500,000	The productive area of coal is much less. Professor Hitchcock estimates the area of the true carboniferous system at 230,659 square miles.
China	400,000	This estimate is not thoroughly reliable, but it is certain that there is an enormous coal-bearing area in China.
Australia	240,000	In New South Wales, the coal area is said to be 120,000 square miles. In Queensland the same area is supposed to exist.
Russia	150,000	This area is probably far below the real extent of the Russian coal-formation.
India	35,000	
British America	18,000	
Great Britain	12,000	Mr. Hull gives 5,431 square miles as being stored with coal to a depth of 4,000 feet.
Spain	8,000	This estimate is vague. Some authorities give 4,000 square miles, and others 2,000.
Japan	6,000	
Germany	3,000	By Germany is meant all the German-speaking provinces, except those under Austrian rule.
France	2,400	
Austria	2,000	Some of the Austrian brown coal seams approach the Indian seams in thickness.
Belgium	520	
Trinidad	318	

Borneo	The coal of Labuan is reported to be of good quality, and very fair coal occurs in the Sarawak territory.
Brazil	There are large coal-fields in this splendid country.
Cape Colonies	There is coal in this as in so many other dependencies of the English crown.
Denmark	Only a small quantity of coal is raised in the island of Bornholm.
Falkland Islands	These islands contain coal.
Greece	Lignites have been worked at Koumi.
New Granada	The coal of this country is said to be cretaceous.
New Zealand	The calculated amount of coal in New Zealand is four thousand millions of tons.
Persia	A large area of coal is stated to occur.
Portugal	A small coal-field exists near the mouth of the Douro.
Zambesi	This coal was brought to light by Livingstone.
Zanzibar	Some coal, said to be Zanzibar coal, was analysed by Mr. Tween, of the Geological Survey, and gave—
	Carbon ... ... 42·4 Volatile matter ... 30·4 (moisture 4 per cent.) Ash ... ... 27·2 100·0

The geographical positions of most of our fields have been already indicated in the "Coal Resources of India" compiled by Dr. Oldham and published in 1867. It was pointed out in that work that a chain of coal-fields extended across India from near Calcutta to the Haidrabád Assigned Districts (the Berars), lying within the 20° and 25° parallels of north latitude; that other fields occurred in the valley of the Godávarí and its affluents, and that throughout Assam, Burmah, and the Tenasserim province there were deposits of coal.

Some of these fields lie in the route of direct railway communication between Bombay and Calcutta, and of course would prove useful sources whence to draw fuel. But the geographical positions of others again are such that they will probably not answer any useful purpose for many years to come.

The quality of Indian coal is usually denoted by the adjective *bad*, but I believe this word has been too freely used. The average of Indian coal is certainly inferior to that of English; but there are many seams in the Ráníganj field, and more notably one or two in the Karharbári field, which yield very good coal indeed. Much of the Assam coal is said to be excellent. And it is justifiable to entertain the idea that if our fields had been more extensively opened out and worked to a greater depth, coals would have been met with of a quality sufficiently good to make us cautious in regard to the indiscriminate use of the word bad. Several attempts have of late been made on one of the short lines of the north of England to burn inferior coals in the locomotive engines; and I have been informed by a gentleman personally interested in the matter that the experiment in which he was concerned proved very successful. The principal modifications of existing arrangements are, I believe, in connection with the grate and draught, but there are minor ones with which I am not acquainted. Nearly the same amount of work, it is stated, was done by the inferior coal as is at present done by the best locomotive coal. How important these practical experiments are in respect to India no one will deny, and I hope the day is not far distant when we shall profit by them.

CHANDAH,
1st January 1873.

On the Salt-springs of Pegu, *by* William Theobald, *Geological Survey of India.*

Prior to the occupation of Pegu by the British, a considerable manufacture of salt was carried on inland, from the somewhat feeble brine springs, which are so plentifully distributed throughout a large portion of the valley of the Irrawadi, more particularly along the eastern skirts of the Arakan range in the districts of Myanoung and Henzadah. Of late years, this manufacture has to a great extent ceased, and is now merely practised on a very reduced scale at a few spots, to supply strictly local requirements. The decay of this industry arises from the abundant supply of the article, now procurable, manufactured in the delta* from sea-water; and we may expect this sea-salt entirely to supplant that manufactured from the springs, as the system of traffic and barter, by means of itinerant traders, enlarges more and more, and the facilities for obtaining the cheaper article become greater, and, therefore, more appreciated. Even now, many spots are pointed out, from which salt was formerly obtained, but at which the precise locality of the wells, long since fallen in, has been forgotten, and every year makes it more difficult to gather information on this point, as the action of the seasons and the growth of vegetation combine to efface all traces of former workings. In some places skirting the hills, the plough now passes over ground where salt-wells formerly existed; and hence it is mainly in the localities where massive timbering was employed to support the sides of the wells that we can best judge of the number and importance of the old workings.

The wells vary in shape, being either round or square, usually the latter, from the greater facility of timbering the sides; whilst some are little better than rude excavations or enlargements of an original cavity, sufficient to permit the accumulation of the brine for convenient removal. Others again are sunk 10, 20, or 30 feet, and have their sides roughly, though effectively, supported by stout planks. In some instances (*e. g.*, Hlahndeng and Kadeng-mah-ngo), these planked wells are sunk to a small depth in the bed of a stream, and during the monsoon become filled with sand, gravel, and fresh-water, but on the season for active operations commencing in the cold weather or towards its close, it was customary to clear them out, when the brine would be found, occupying its own place, a short distance below the ordinary level of the bed of the stream.

The strength of the brine is variable, being often only feebly saline. This probably depends on admixture with surface water, as the strongest noted was yielded by the Sadwingyee spring, which was also most copious, and consequently the least obnoxious to admixture with surface water, which may be supposed often to affect the more feeble and sluggish springs. I may here remark that, though usually spoken of as brine *springs*, these springs are, in the great majority of instances, hardly entitled to the designation, having scarcely any flow. In the case of Sadwingyee, there is a copious spring. In the case of Nummayahn and Sahngyee there is a perceptible flow, and no more, accompanied by a somewhat copious evolution of marsh-gas, which keeps the pools turbid and in a state of constant ebullition. The more usual mode of occurrence of the brine, is among crushed or disturbed strata, especially harsh dark shales, in which the brine occupies cracks and pockets, and, on a well being sunk therein, trickles into it from the surrounding strata, but without causing an overflow. Mr. W. T. Blanford, in a memorandum on the salt-wells of the district of Henzadah (May 1st, 1861), points out thirteen different localities, the richest being that at Sadwingyee, which indeed may be regarded as the richest in the province, and of which I here quote his account.

"The appended list specifies thirteen† different localities in the district of Henzadah at which salt is known to have been worked. Of these, only three were at work at the time

* Imported English salt is now competing with the country-made article.

† Nos. 63 to 69, 71 to 74, 79.

of my visit, the principal of which was Sadwingyee, the spring at which place is probably one of the most productive yet known in the region. The flow of water in the well was carefully measured by my fellow assistant, Mr. Fedden, and found to be 57·15 gallons per hour, or about 1,370 in the 24 hours. By a rough experiment the water was found to contain 4,704 grains of salt to the gallon, so that the quantity of salt daily yielded by this spring amounts to 920 lbs. avoirdupois, or 8 cwts. 24 lbs.

"Few springs probably yield so largely as Sadwingyee, but it was not found practicable to ascertain the quantity procurable from any other. The water is so salt that it can be evaporated at once without previous partial evaporation by the sun. It is boiled down in large iron pans, placed in twos or threes, over an earthen fire-place, the method being somewhat similar to that employed in India for evaporating the juice of the sugarcane."

The pans mentioned in the above paragraph are shallow, extremely thin cast-iron pans, of English manufacture, of about 30 inches in diameter, and principally used in the preparation of the common 'jaggery' or unrefined sugar from the juice of the 'date,' 'fan,' or other palms. Earthen pots are also used for concentrating the brine, of an oval shape, with sides nearly an inch in thickness, and capable of holding between 3 and 4 gallons. In the delta, where salt is habitually made from sea-water, a somewhat different arrangement is adopted. A circular oven of brick is constructed, something like a large bee-hive, with holes at intervals to receive the oval earthen pots above described, to the number, perhaps, of as many as sixty in one oven, the ultimate concentration being, I believe, in the ordinary shallow iron pans, though this is probably a recent innovation.

The distribution of these springs is as follows:—Of 79 localities recorded in the accompanying table, 21 are situated within the area occupied by the newer tertiary strata of the province, of miocene age; 9 within the much narrower belt of country formed of unaltered, and comparatively slightly disturbed, nummulitic rocks; whilst most of the remaining 49 localities form a conspicuous band along the outer hills, on the eastern side of the Arakan range, among altered rocks, grouped comprehensively under the term Negrais beds, of, in part possibly, nummulitic age likewise.

No salt springs are known to me on the western side of the Arakan range, or on the eastern side of the Pegu range. The whole are, as far as is at present known, confined to the Irrawadi valley; though future exploration may possibly show that this remark only holds good within the area to which it more immediately relates.

The most easterly springs are those of Kadeng-mah-ngo and Pyeng-mah-choung, fifty miles to the south of the former, distant, respectively, sixty-seven and seventy miles from the Arakan range, and thirteen and eleven from the Pegu range, measured at right angles to their general direction. Seven miles south of the Pyeng-mah-choung springs occurs the spring of Toung-ngo, rising on the same north by west line of strike, and being accompanied by a copious evolution of marsh-gas. The Toung-ngo spring rises on a line of disturbance, as shown by the crushed and indurated character of the sandstones in its vicinity, and the lesser frequency of springs along this most easterly line of their occurrence may be partly attributed to the greater thickness of the newer strata, which they would here require to pierce before reaching the surface; and, partly, to their presence not having been so sedulously sought after by the natives, owing to the lesser demand for salt at such a distance from the river or lakes, yielding the great bulk of the fish from which the national gna-pee or fish-paste is prepared. Hlahndeng spring probably belongs to the same system, though situated a little off the direct line on which the others rise.

The second line of springs is that of which Nummayahn is the most important, and runs in a direction north by west, distant, respectively, thirty-two and forty-six miles from

the Arakan and Pegu ranges. The On-nay-da-gyee spring near the frontier lies almost exactly on this line, which, if considered as one line, measuring from On-nay-da-gyee to Waddau-tha, is sixty-three miles in length, with a general coincidence of direction with the hill ranges bounding the valley.

On this line likewise is situated the spot known as Naht-mi or "the spirits fire," thirty miles north by west from Nummayahn, and which is merely a spot in the jungle from which marsh-gas issues through cracks in the soil, and becomes, from time to time, either intentionally ignited or accidentally during the prevalence of jungle fires. Above Nummayahn, in the river bed, there is considerable disturbance, as evinced by vertical strata, and it seems probable that all the springs of this group rise along one and the same line of fracture, probably a highly contorted anticlinal, though this may not be indicated by the appearance of the rocks at the surface, at the actual point of issue of the springs, which may mainly depend on local conditions, surface arrangement, denudation, and the like.

A little west of this line occur other springs (Nos. 8, 21, 9), which may or may not issue primarily along the same subterranean line of disturbance or fracture; but this is neither material nor possible to say.

Associated with this system of springs may be classed the Boolay, Laymyoung, and Tayzahn springs. The Boolay springs were simple wells sunk in sandstone at the mouth of the Boolay stream, but which have been long disused. The Laymyoung spring rises on the top of a low ridge forming mud pools from which a little marsh-gas escapes, much after the fashion of the Nummayahn springs, only much more feebly. Near the mouth of the Boolay stream, above where the road crosses, and close to the village of Kwonboolay, occurs the only hot spring known to me in Pegu, but it rises in the bed of the river, so that its temperature cannot be well ascertained, and sometimes it is entirely concealed beneath the sand.

The third line of springs is by far the most important, embracing probably several closely arranged parallel lines; and if we assume the Sahngi spring on the frontier to belong to this group, this line would seem to follow a curve, generally corresponding with that followed by the Arakan range. The Sahngi and Day-beng springs are situated in a line thirty-four miles long, with a general bearing north-west by north, with the Lengbhan and Shuagyeing springs a little on either side of it, and distant seventeen miles from the Arakan range. From Day-beng to Shah-si-bo the line is forty-two miles, with a bearing north by west, distant fourteen miles from the Arakan range, and marked by a perfect belt of salt springs. From Shah-si-bo southwards, the springs are rather more scattered, and run in a direction almost due south, the most southerly one recorded, No. 79, being one hundred and twenty-four miles in a straight line from the frontier spring of Sahngi.

This rich belt of springs is situated among a group of harsh dark indurated shales and sandstones; the induration being variable in amount, and never approaching metamorphism, properly so called, within the area immediately adjacent to the salt springs in question. Few or no fossils have been found in these rocks, certainly not within the above area, but their relation to the unaltered rocks of the district lends support to the view of their being possibly of nummulitic age.

In view, then, of the occurrence of these springs most numerously along lines corresponding to the general strike of the beds of the district, and of the direction, moreover, of the twin ranges which bound the Irrawadi valley; and having regard to the indications of compression and violent disturbance which the rocks in their vicinity often display; in view, too, of the association with them, on the same lines of strike, of the only hot spring in the province, and of spots whence issue both petroleum and marsh-gas, we may fairly assume that they rise along widely extended lines of disturbance, (anticlinal fissures most probably,) from the lower beds of the nummulitic or some still older group.

It may here be remarked that whereas the only known petroleum localities lie within the area of unaltered nummulitic strata, or of the newer Tertiaries, yet the greater number of salt springs lie below this horizon among the altered and presumedly lower members of the same group; a point which, if definitely established, as it seems to be, as far as regards the area hitherto subjected to examination, will not be without an important practical bearing in searching for petroleum, inasmuch as there is an idea prevalent that the presence of brine springs in this region is *per se* indicative of the existence below of the more valuable mineral. Having regard to the circumstances under which the mineral oils occur in America, there is nothing unreasonable in the supposition of a similar connexion existing between the brine springs and oil in Pegu, as is found in the new world—an idea strengthened, moreover, by the existence in the same districts of both oil and brine; but, as I have already pointed out, there seems no good reason for believing that, in Pegu, the same connexion between brine springs and oil exists as in the American oil-fields. On the contrary, it would seem that the reverse of what occurs in America is to be anticipated here. In America the connexion between the oil and brine is an established fact; the first petroleum obtained by boring having been accidentally obtained in 1819 "in sinking wells for salt in the little Maskingum river in Ohio," (Erni, "Coal-oil and Petroleum.") In Pegu, it would seem as though, if in sinking a bore, a copious brine spring were struck, this would probably indicate that the boring had penetrated to a horizon below that wherein the mineral oil was produced. In Pegu, as in America, the oil may rise to the surface with the brine, as the horizon of the napthagenic beds is higher than the sources of the brine, which is not the case in the American oil-field. But the non-association of the two in Pegu may, I think, be legitimately inferred from the fact of no indications of petroleum being known within the belt of rocks wherein the most numerous brine springs rise, as would hardly fail to be the case were the origin of the brine and petroleum in one and the same group of beds. That the co-existence, too, of brine springs and petroleum in Pegu is rather a fortuitous than a connected phenomenon (as it would seem to be in America,) is to some extent borne out by the fact of petroleum occurring in the Punjab in connexion with rocks of the same geological age as in Pegu, but without the accompaniment of brine springs, as in that province; so that our present experience may be summed up with the assertion, that whilst a copious discharge of brine and marsh-gas may not be without value in determining a site for sinking for petroleum, in ground occupied by rocks of the upper portion of the nummulitic group or any rocks above that horizon, yet the same indications are not to be relied on as of equal promise, within the area occupied by rocks lower in the series, or of greater geological age.

It only remains to add a few words explanatory of my classing these altered or hill rocks as 'Negrais beds,' or possibly nummulitic in part, after having, in my recent paper on the 'Axials in Western Prome,' included them in that group. When writing that paper, the age of these hill-rocks was quite problematical, and beyond the general absence of fossils in the limestones and the mineral character of the beds, so different from that of the recognised Nummulitics, there was little or no evidence to which group they should be assigned; and the balance seemed to tend towards their union with the older or axial group. During the following season, however, (1870-71), I accumulated evidence, of an opposite tendency, not only by a more extended examination of the ground occupied by them, but I had the good fortune likewise to detect Nummulites in one of the outcrops of limestone, alluded to by me in note at page 38 (loc. cit.), which I had not previously had the opportunity of visiting, thereby demonstrating the relation of a portion at least of these hill rocks, of hitherto uncertain age, with the newer nummulitic group, in spite of their often excessively changed character, rather than with the older Axials, with which they had been previously included. I must defer, however, a discussion of this question for another occasion.

CALCUTTA,
6th August 1872.

W. THEOBALD.

I append a list of springs, a great number of which are not included in the published map of the province. I have therefore spelt the whole on a uniform system as given below, adding the mode used in the published map, where it differs from my own. I have endeavoured to convey the sound, so that the word cannot be mis-pronouuced through ignorance or ambiguity. The system is that already adopted in the naming of a very extensive collection of Pegu woods presented to the 'Phayre Museum', Rangoon.

Burmese names spelt on the following system:—

a	as	a	in	m*a*t	c*a*t
ah	,,	a	,,	f*a*ther	*ah*
y	,,	i	,,	s*i*n	s*y*ncopy
ei	,,	i	,,	n*i*le	n*ei*ther
o	,,	o	,,	p*o*t	l*o*t
oa	,,	o	,,	p*o*pe	s*oa*p
u	,,	u	,,	t*u*b	m*u*d
oo	,,	u	,,	l*u*nar	st*oo*p
ay	,,	a	,,	p*a*tient	st*ay*
e	,,	e	,,	s*e*t	m*e*t
i	,,	e	,,	imp*e*de	concert*i*na
ew	,,	e	,,	f*ew*	n*ew*

There is no *f* in Burmese, *hp* is its nearest representative; *g* is always hard.

Nos.	Report Spelling.	Map Spelling.	Remarks.
1	Hlahn-deng ...	Hlandeng ...	One and half mile west of the village. Several wells in the rocky bed of a stream, and a few more a little to the eastward.
2	Kadeng-mah-ngo ...	... ...	Several wells in a small stream running into the Khyoung-khoung.
3	Pyenmah-choung ..	Pyengmakhoung ...	Two springs or puddles a little way apart.
4	Toung-ngo ...	... ...	A strong spring with much marsh-gas escaping. Water very nauseous.
5	Sahn-gi	Sangyee ...	Several springs with a copious evolution of marsh-gas, but a feeble discharge of brine.
6	Hpoongi	Pwongyee.	
7			
8	Oan-nay dah-gi ...	On nay dagyee.	
9	Ki-deing.		
10	Boolay	Bhwet-lay ...	Several wells sunk in sandstone on the north bank near the mouth of the Boolay-choung.
11	Lay-myoung ...	Let myoung ...	Springs issue feebly on the top of a small hill, with a little marsh-gas.
12	Tayzahn	Tazan.	
13	Leng bahn ...	Leng bhan.	
14	Shuay-gyeng.		
15	Day-beng.		
16	Nyoung-kein.		
17	Yathaya	... ...	Several wells about one mile south by west from the village.
18	Hsengahn.		
19			
20	Oat pho	Ot pho.	
21	Num-may-ahn ...	Na ma yan ...	Several springs, rather feeble, but with a considerable evolution of marsh-gas about half a mile south-east of town on rising ground.
22	Pyouk-hsiaht.		
23	Pay-goan.		Nos. 21 to 26 all rise along the west side of the range of hills running down behind Prome in a south-easterly direction.
24	Ynah-thyt-koan.		
25	Thoan-ua boung.		
26	Wuddau-thah.		
27	Bhooyo.		
28	Hnet wah	... ...	Several wells.
29	Kahngu choung ...	... ...	The brine here rises in a sort of pocket formed by a crushed anticlinal, and we have here probably exemplified the manner in which most of the springs reach the surface, along lines rendered pervious by extreme folding, and the disruption of the lower beds.
30—35	(33) (38).		
36	Zigoan-choung.		
37			
38	Toung-myouk-choung.		
39			

Nos.	Report Spelling.	Map Spelling.	Remarks.
40—46	Hlay-gu	... ...	These seven localities embrace many wells ranged in a line one and half miles long. They are now mostly abandoned.
47	Kamyeng-choung.		
48			
49	Shuaybandau.		
50			
51—53	Kweng-hlah.		
54 & 55	Oashyt-Kweng.		
56	Thayetsahn.		
57	Paybeng-goan.		
58	Chin-uah-gi.		
59			
60	Sayay-kweng.		
61	Shah-si-bo.		
62	Kway-mah	... ...	There are some six wells here.
63	Khyon khya ...	... ...	The brine of Nos. 63, 64, and 65 said to be very salt.
64	Hsi-soan.		
65	Tsahnda-choung, *N.*		
66	Ditto, *S.*		
67			
68	Piah-hoan.		
69	Boodalet.		
70	Mioung.		
71	Sahdwyngi ...	... ...	This is the most copious and important spring in Pegu.
72	Adwynzyn.		
73	Kayahndwyn.		
74	Minahgwyn ...	... ...	There is a cluster of some thirty wells here within a mile of this.
75	Kway choung kweng.		
76	Thayet-goan.		
77	Wuddaw kweng.		
78			
79	Hlay goan.		

Nos. 63, 64, 65, 66, 67, 70, 71, 72, 73, 74, and 79 had been already examined and fixed by Mr. W. Blanford. The great majority of the remainder have been visited by myself, whilst many of them have been independently examined by Mr. Fedden likewise. It must not, however, be supposed that the above list exhausts all the localities where brine may possibly occur, but only attempts to give as complete an enumeration as possible of the sites where salt has been formerly extracted.

DONATIONS TO MUSEUM.

FROM 1ST APRIL TO 30TH JUNE 1873.

APRIL 25TH.—DR. HENDERSON.—Two specimens of Limestone and Sandstone from the north slope of the Korakoram Range.

JUNE 10TH.—Government of India through A. W. SAMPSON, ESQ., Under Secretary. Specimens of Earth-Oil collected by B. L. SMITH, ESQ., from the Punjab.

ACCESSIONS TO LIBRARY.

FROM 1ST APRIL TO 30TH JUNE 1873.

Titles of Books. *Donors.*

AUSSET, DOLLFUS.—Matériaux pour l'Etude des Glaciers, Vol. I, Part IV, (1870), 8vo., Paris.

AUSTIN, JAMES G.—A practical treatise on the preparation, combination, and application of Calcareous and Hydraulic Limes and Cements, (1862), 8vo., London.

BLAKE, WM. P.—Notices of Mining Machinery, (1871), 8vo., New Haven.

DESOR, E., ET LORIOL, P. DE.—Échinologie Helvétique. Description des Oursins Fossiles de la Suisse, with Atlas, (1868-72), 4to., Paris.

DUPONT, E.—L'Homme pendant les Ages de la Pierre dans les environs de Dinant-sur-Meuse, 2nd Edition, (1872), 8vo., Bruxelles.

FERGUSSON, JAMES.—Rude Stone Monuments in all Countries; their age and uses, (1872), 8vo., London.

FRITSCH, DR. ANTON.—Cephalopoden der Böhmischen Kreideformation, (1872), 4to., Prag.

FROMENTEL, E. DE.—Introduction a l'Étude des Polypiers Fossiles, (1858-61), 8vo., Paris.

HARCOURT, CAPT. A. F. P.—The Himalayan Districts of Kooloo, Lahoul, and Spiti, (1871), 8vo., London.

LEAVITT, T. H.—Facts about Peat as an article of fuel, (1867), 8vo., Boston.

Matériaux pour la Carte Géologique de la Suisse, Parts 6 to 9, and 11, (1869-1872), 4to, Berne.

MEUNIER, STANISLAS.—Cours Élémentaire de Géologie Appliquée, (1872), 8vo., Paris.

MORFIT, C.—A Practical Treatise on Pure Fertilizers, (1873), 8vo., London.

ORMATHWAITE, LORD.—Astronomy and Geology compared, (1872), 8vo., London.

PALMIERI, PROF. L.—The Eruption of Vesuvius in 1872, (1873), 8vo., London.

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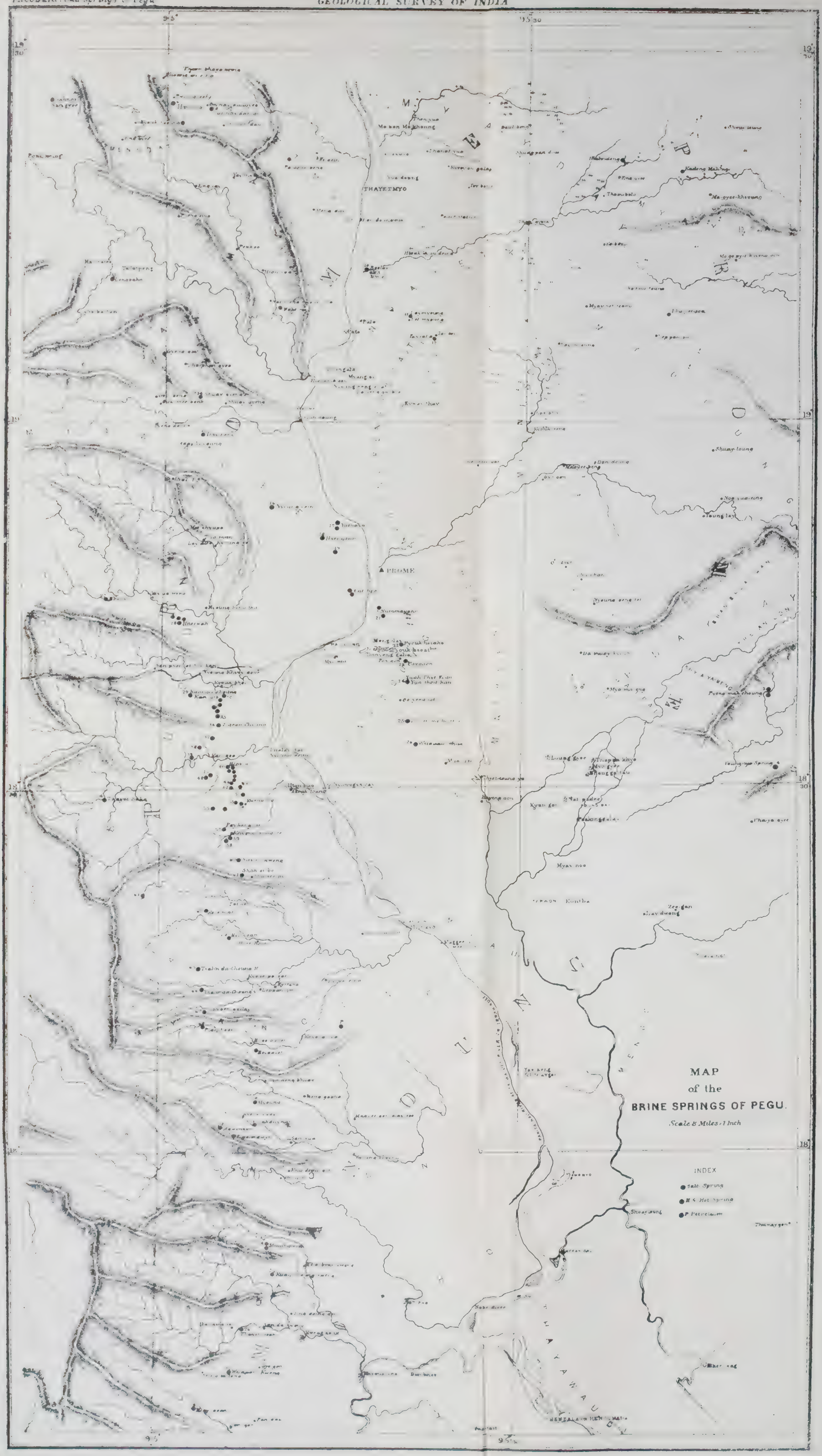
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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1873. [November.

Note on some of the Iron deposits of Chándá, Central Provinces, *by* Theodore W. H. Hughes, A. R. S. M., F. G. S., *Geological Survey of India.*

My present contribution to the Records of the Geological Survey refers to a few only of the deposits of iron-ore found in the Chándá district, and gives some details relative to the amount of ore and fuel ordinarily used in native furnaces, showing what results are obtained without the use of foreign slag-forming ingredients.

I am indebted to Major Glasfurd, the Deputy Commissioner, for my quantitative figures; and although it is always more satisfactory to have an accumulation of data, I think the six experimental trials which are recorded yield a fair indication of the work accomplished by the method of smelting adopted in this country.

Iron-ore exists in great quantity; and as it occurs principally in the metamorphic rocks, it is found in those portions of the Chándá district which are to the north and east of the main Wardhá valley coal-field. Anhydrous hæmatite is the most abundant species, and it furnishes all the supplies for the native furnaces. It is usually compact, and is mixed up occasionally with some magnetic oxide and a little brown iron-ore.

The latter variety of hæmatite occurs often as a coating to an interior mass of anhydrous hæmatite. It presents in many instances an exceedingly beautiful appearance, having a clear smooth surface on the outside, and being finely fibrous on the transverse face. There is no difficulty in distinguishing it, for it gives a well defined brown streak on being scratched; and any person interested in possessing an illustrative mineralogical sample of iron-ore, showing the passage of one variety into the other, may obtain in the Chándá district many such specimens as that which I have described.

The most noted localities for abundance and excellence of ore are Déwalgaon, Gúnjwáhí, and Lohárá; but there are several others which run them close for a place in the first rank. The wealth of Chándá in iron-ore is undeniable. In the form either of magnetic oxide, hæmatites, carbonate, or as laterite, one is constantly meeting with it.

The deposit most worthy of notice which I have hitherto seen is undoubtedly that at Lohárá. It deserves, and will some day obtain, a more than local reputation. The ore consisting of compact crystalline hæmatite or specular iron-ore with some magnetic oxide, forms a hill fully three-eighths of a mile in length, two hundred yards in breadth, and a hundred to a hundred and twenty feet in height. The main lode striking north-east by north can be traced clearly for some distance beyond the distinctive hill portion which first catches the eye, and its actual length if followed out (but which I am sorry to say I had not time to do on the occasion of my visit) would probably exceed several miles.

The view presented by such a mass as that at Lohárá, exclusively made up of almost pure specular iron, it does not fall to the lot of many men to see surpassed; and those who possess the opportunity of visiting this place ought to do so, and carry away with them the remembrance of having looked upon one of the marvels of the Indian mineral world.

The ore at Lohárá has been analysed by Mr. David Forbes, and I extract from the Colliery Guardian* the following statement of its composition:—

Iron, metallic	69·208
Oxygen, in combination	29·376
Manganese, sesquioxide	·090
Silica	·823
Alumina	·432
Lime	·054
Magnesia	Trace.
Sulphur	·012
Phosphorus	·005
	100·000

It will be seen that it is extremely rich in iron, and exceptionally free from sulphur and phosphorus, which are usually two of the most annoying ingredients that the iron-master has to contend with. The amount of silica is less than would be presumed to exist, judging by the external appearance, compactness, and hardness of the ore.

It is not, however, to the Lohárá deposit that I wish to draw attention so much, as to some others, which—since the question of establishing large iron-works in India has been again raised—have lately acquired increased importance, due to their propinquity to a small area of *possibly* coal-bearing-rocks, about six miles west of Chimúr, which I discovered and mapped during the past season.

These deposits are three in number, and occur near the villages of Bissí, Pipalgaon, and Ratnápúr.

(1). Bissí.—Long. 79°28′ East, and Lat. 20°39′ North. The ore occurs in a lode about a mile directly east of the village, and contains hæmatite and magnetic oxide of iron.

(2). Pipalgaon.—Long. 79°34′ East, Lat. 20°32′ north. An excessively fine mass of red hæmatite, resembling that which occurs at Lohárá, and having probably the same composition, is to be seen about three quarters of a mile east of Pipalgaon. The strike of the lode is west-north-west, east-south-east.

(3). Ratnápúr.—Long. 79°37′ East, and Lat. 20°23′ North. A very rich lode of brown iron ore, forms a terrace on the north side of the small range of hills facing Alísúr. The width of the lode in places is 40 and 50 feet.

The coal rocks which I have referred to as giving increased importance to the deposits just described, occupy a somewhat restricted area. I have not been able to prove the actual existence of coal by the discovery of an outcrop; but Damúdá and Kámthí strata occur; and a very few shallow borings, not exceeding 300 feet at the utmost, sunk between Morepáh

* Colliery Guardian, 13th September 1873.

and Bandar* ought to determine the question. I do not entertain the idea that there is any present chance of profitable blast-furnaces being erected in the Chándá district. We have a long pupilage to go through before we can work successfully with such coal as has hitherto been found in the Wardhá valley field. It may, therefore, perhaps be urged that if this be the case, there is no immediate necessity for proving the ground which I have pointed out. But I am writing with the full knowledge that there is a boring establishment at Warora, and that possibly if the present opportunity of profiting by it be neglected, many years may elapse before mechanical means are again available for purposes of exploration. Should the borings which I recommend be carried out, we shall gain positive knowledge in reference to the rocks, and if there be no coal, we shall not be indulging in vain speculations regarding the utilization of the iron ore deposits to which I have drawn attention.

The native furnaces of Chándá are somewhat taller and larger than those commonly in use in Bengal. Several that I measured were nearly 6 feet in height, owing to a prolongation upwards of the front face of the furnace, the use of which is to back up the ore around the feed-hole. The height of the actual working shaft varies from 4′ 6″ to 5 feet.

The section of the furnace is that of a cone, its internal diameter diminishing from 1′6″ at a height of six inches above the hearth to three quarters of a foot at a height of 36 inches above it.

The hearth, as is usual, slopes from behind forwards, and the bloom is taken out through the face.

The twyers are 9 inches long, $1\frac{1}{2}$ inches in diameter at the larger opening, and $\frac{3}{4}$ths of an inch at the smaller. The bellows for producing the blast are usually worked by hand.

I need not refer to the method of smelting, further than to say that it is similar to the mode in use in other parts of India, and I will now give the results and details of the six experiments which Major Glasfurd undertook to have made.

Three experiments were conducted in the Múhl Tahsíl, at Chikli, Gúláb-bhúj and Metégaon; and three in the Brahmápúrí Tahsíl, at Armorí, Déwalgaon and Injhéwárá:—

VILLAGE.	Iron ore used.	Charcoal used.	Iron yielded.	Cost of iron ore and charcoal used.	Value of iron.	Wages of 2 men.
	Seers.	Seers.	Seers.	Rs A. P.	Rs. A. P.	Rs. A. P.
Múhl.—						
Chikli	49	82	$17\frac{1}{2}$	0 9 0	1 0 0	0 4 0
Gúláb-bhúj	65	88	$13\frac{1}{2}$	0 9 0	0 13 0	0 4 0
Metégaon	72	90	$21\frac{1}{2}$	0 9 0	1 3 0	0 4 0
Bráhmápúrí.—						
Armorí	$37\frac{1}{2}$	68	12	0 4 6	0 9 7	0 3 2
Déwalgaon	52	114	12	0 4 6	0 8 10	0 3 2
Injhéwárá	44	88	$12\frac{1}{2}$	0 5 10	0 10 0	0 3 2

In these returns there is a great discrepancy in the price paid for charcoal and ore in the Mhúl and Brahmápúrí Tahsíls. Compare, for instance, Chikli (49+82 seers for 9 annas)

* Morepah: Long. 79° 21′ East; Lat. 20°33′ North. Bandar: Long. 79°21′ East; Lat. 20° 30′ North.

and Déwalgaon (52+114 seers for 4*a.* 6*p*). The yield of iron also shows great disagreement. At Déwalgaon 52 seers of ore produced only 12 seers of iron, whereas at Chikli 49 seers produced 17½. It may be that a poorer class of ore was used in the one instance than in the other, but I scarcely think this can be the case, for I have always observed that the natives invariably used ore having the same average composition. And an analysis of the Déwalgaon ore shows that it contains 70 per cent. of metallic iron.

If we calculate the proportion of the amount of charcoal used to iron ore, and the proportion of the amount of ore employed to the iron produced, we find:

Village.	Proportion of ore to charcoal.			Proportion of ore to iron.		
	Ore.		Charcoal.	Ore.		Iron.
Múhl.—						
Chikli	1	to	1·7	3	to	1
Gúláb-bhúj	1	"	1·4	5	"	1
Metégaon	1	"	1·2	3·5	"	1
Brahmápúri.—						
Armorí	1	"	1·8	3	"	1
Déwalgaon	1	"	2·2	4·3	"	1
Injhéwárá	1	"	2·0	3·5	"	1

The iron referred to above, which is called *kít* by the Maharattas, is a mere mass of spongy iron, slag and charcoal, and has to undergo two refinings before being sold as malleable iron. In the first operation it is manipulated by the men who reduce it from its ore. They heat it in a refinery, and then hammer it, whereby the slag is more or less completely extruded and the iron consolidated into a compact bloom. It loses considerably in weight during this process, and the mass formerly weighing, say 14 seers, is diminished to 10 seers. The amount of charcoal consumed is stated to be 20 seers, or perhaps a little less. The bloom is then cut partially in half and is called *Chúl*, and is sold to the regular metal-workers (lohars). These men clean it again, by which its weight becomes still further reduced, fully one-third and sometimes one-half of it being lost; and it is by them worked up into various household and agricultural implements.

Applying the foregoing observations (by taking the mean of the Múhl figures) to arrive at the average proportions of iron-ore and charcoal used in producing iron ready for being actually worked up, it appears that—

(*a.*) Seventeen and a half seers of iron are produced from 63 seers of ore and 87 seers of charcoal.

(*b.*) In the first refining operation, 20 seers of charcoal are used, and the iron loses 5 seers in weight, reducing it to 12½ seers.

(*c.*) In the final refining operation about 10 seers of charcoal are consumed, and clean workable iron, weighing 7 to 8 seers, is obtained.

Thus, 63 seers of ore and 117 of charcoal are required by the native method of smelting as carried on in Chándá to produce 8 seers of metal. Or, stating it in current English terms—

$$\left.\begin{array}{c}\text{8 Tons of ore}\\ \text{and}\\ \text{14½ Tons of charcoal}\end{array}\right\}\ \text{Are used in the manufacture of 1 Ton of wrought-iron.}$$

There is no occasion in the present number of the Records to treat the subject of cost in its various branches, nor need I enter upon a discussion of the commercial aspect of the iron trade of Chándá. I hope to dwell at some length upon both these topics when giving a detailed description of the Wardhá valley coal-field.

For the present, I wish to draw attention to 1*st*, the richness of Chándá in iron-ore; 2*nd*, the circumstance of the *probable* favorable association of coal and iron-ore; 3*rd*, the proportional consumption of raw materials in the manufacture of native wrought-iron. Of course, should furnaces intended either for the making of pig-iron, or for the production of wrought-iron by the direct process, be ever erected on a European scale, the data afforded by observations on the liliputian works of the natives of the country will be matter for curiosity rather than of practical interest.

CALCUTTA,
1*st July* 1873. T. W. H. HUGHES.

BARREN ISLAND AND NARKONDAM, *by* V. BALL, M. A., *Geological Survey of India.*

In the month of March last, a few hours were spent on the two Islands whose names are given above by a party consisting of Mr. Hume, Dr. Stoliczka and myself. Although the time at our disposal did not admit of extended exploration, still an opportunity was afforded of checking the accuracy of the accounts which have been previously published.

Having consulted every notice of these islands which, so far as I have been able to ascertain, have hitherto been published, I have been astonished to find how inaccurate has been the information upon which the accounts in Geological Manuals and other works have been founded.

In the present paper I have devoted several pages to an abstract of these accounts, and have pointed out the errors and traced, so far as is possible, their origin.

Dr. Liebig's paper on Barren Island which contains the fullest and most accurate account of the island hitherto published, does not appear to have reached the hands of several authors who have since its publication repeated the old statements in their works.

Barren Island and Narkondam are two volcanic islands situated in the Bay of Bengal at a distance of 70 miles from one another on a north-by-east, south-by-west line. They constitute links which connect what is known as the Molucca band with the volcanic region of Arracan and Chittagong, and of which Mrs. Somerville has written as follows:—

"One of the most terribly active groups of volcanoes in the world begins with the Banda groups of islands, and extends through the Sunda groups of Trimor, Sumbawa, Bali, Java, and Sumatra, separated only by narrow channels; and altogether forming a gently curved line 2,000 miles long; but as the volcanic zone is continued through Barren Island and Narkondam in the Bay of Bengal and northward along the Coast of Arracan, the entire length of the volcanic range is a great deal more."

Dr. Hochstetter carries the line of elevations which accompanies the zone of volcanic action still further, in an oblique S. form, through New Guinea to the north of the Australian continent. "It forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie Islands being possibly considered as the extreme southern end of this curve."

So far as is known, there are no volcanoes in either the Nicobar or Andaman Islands. It has been by some supposed that the hill on Bompoka in the Nicobars and some of the

high ground in the great Nicobar might be volcanic, but the evidence is rather against than in favor of this view. Plutonic rocks (diorite and gabbro) not unfrequently occur however in both islands. A statement made in an old account of the Cocos, that the little Coco is formed of volcanic rocks, is quite without foundation.

BARREN ISLAND, Lat. 12° 17′, Long. 93° 54′.

History of the island derived from previous notices.—In the table appended I have given a *précis* of all that has been published on the subject of Barren Island; but a few additional remarks tracing out the way in which certain inaccuracies have arisen seem to be desirable.

The first account was by Captain Blair, in his report on the Andaman Islands, dated 1789. I have not seen the original document, but the account was extracted and reprinted by Lieutenant Colebrooke in the Asiatic Researches. It has served for many years as the text upon which the descriptions published in various Geological Manuals have been founded.

Captain Blair gave the height of the central cone at nearly 1,800 feet, and the angle of the slope at 32° 17′. Were it not stated that the cone was equal in height to the outer walls of the surrounding part of the island, we might, in consequence of Blairs' oft proved accuracy as an observer, be disposed to believe that at the time of his observation the cone was nearly double its present height. That there has not been a general subsidence of the island to the extent of 800 feet is proved by the fact that the base of the cone was then, as it is now, but little raised above the sea level. Blair himself states that it may be seen at a distance of twelve leagues in clear weather, which would only require an elevation of about 920 feet. I can only suppose, as an explanation of the difficulty, that Blair took several heights which varied between 800 and 1,000 feet, and that these, by some error, came to be written together as 1,800.

The angle of inclination of the sides of the cone is given by Blair at 32° 17′. This nearly corresponds with the mean of my observations, which ranged between 32° and 35°. These angles also agree with those on a photograph which I possess. Dr. Liebig, Dr. Playfair and others have given it at from 40° to 45°.

The sketch by Lieutenant Wales given in Lieutenant Colebrooke's paper, save that it represents an inclination of about 60° to the sides of the cone, conveys the best idea of the island of any of the numerous figures which have been published. It was reproduced by Von Buch, and copied from him by Sir Charles Lyell, Dr. Daubeny, Dr. Buist, &c. Von Buch, in his "Memoir on the Canary Islands," gives the height of the cone at 1,690 Paris feet. His account, though apparently derived from Lieutenant Colebrooke's paper alone, contains the statement that the sea penetrates into the circle at the base of the cone. This can only have been due to some misapprehension of the meaning of Blair's words, which were as follow: "The base of the cone is the lowest part of the island and very little higher than the level of the sea."

Sir Charles Lyell, in the earlier editions of the 'Principles,' framed his account from Von Buch's. In the changes from English into French, and back again into English, the elevation of the cone became increased by 48 feet, standing in the 7th edition of the 'Principles' (1847) at 1,848 feet. It is also there stated that the circular basin inside is filled with the waters of the sea. In the 9th Edition, 1853 (I have not been able to refer to the 8th), Captain Miller's estimated elevation of 500 feet is adopted instead of the former one; but the statement

regarding the sea inside still remains. In the 10th Edition (1868) Captain Miller's estimate of 500 feet, as the height in 1834, is retained; but it is stated that according to Von Liebig in 1857, both the cone and outer crater were about 1,000 feet high, and in reference to the sea we find the following: "In some of the older accounts the sea is described as entering the inner basin, but Von Liebig says it was excluded at the time of his visit." I believe this statement regarding the sea to have arisen solely in the way I have pointed out. It is important that there should be a clear representation of the case, as otherwise it might be concluded that we have evidence of the rising of the island within the historical period.

The next account to that by Blair is by Horsburgh, about which there is nothing particular to remark here, save that he asserts that in 1803 the volcano was very active (see table).

Dr. J. Adam's account is derived from information and specimens received from a friend who had landed on the island in 1832. He speaks of the stones on shore hissing and smoking, and the water bubbling all round them. The statement has apparently been understood by one writer to indicate that the lava had not then cooled down. But the hot spring was probably quite sufficient to account for the phenomena observed. This is the first mention made of the hot spring. The author supposes that the volcano is only active in the south-west monsoon, *i. e.,* requires water to bring it into a state of activity. Apart from other considerations, it is only necessary to say that the only authentic account of it in a really violent state of eruption is by Blair, who saw it on the 21st of March, and therefore not in the south-west monsoon. Captain Miller's account is very inaccurate in several respects. He has given the height at 500, and the angle at which the cone rises at 45° or even more. If the elevation of the cone in his time were only so much, then, since he states that this was also the elevation of the outer walls or amphitheatre, both must have increased *pari passu.* This view is of course untenable, and we are forced to believe that Captain Miller only gave a rough guess. His remarks on the vegetation are quite inconsistent with one another, for he says,—"there is no vegetation of any kind within the amphitheatre, but *a few small trees* are found on other parts of the island, which, however barren it may have been at one time, is *now well wooded.*"

Dr. Daubeny, in his description of Barren Island, though quoting from Lieutenant Colebrooke, gives the elevation of the cone at 4,000′, which must have been due to a clerical error. A somewhat modified reproduction of the original sketch is given.

Mr. Scrope, in his work on Volcanos (*2nd Edition, Lond.,* 1862), writes regarding Barren Island: "This permanently active volcano is a cone about 4,000 feet high, rising in the centre of a circular cliff range, which entirely surrounds it except at one point where the sea has broken in." Though the authority is not given, it is evident that this account is derived from Dr. Daubeny's, as the elevation is not given at 4,000′ in any other work.

In 1846 the island appears to have been visited by the Danish corvette *Galathea*, but the only record of the fact which I know of is an inscription on a rock on the island—"*GALATHEA*, 1846."

In the *Bombay Times* for July 1852, on the authority of Dr. Buist, it is stated that the volcano was very active, but I have not been as yet able to refer to the original account.

The chief points in the accounts subsequent to the above will be found incorporated below. Dr. Playfair, Von Liebig, and the Andaman Committee agree in estimating the angle of the cone at 40° to 45°, and the elevation at from 975—980 feet.

Abstract of the published accounts of Barren Island.

Year.	Authority.	State of Activity.	Slope of Cone.	Elevation.	Temperature of Hot Spring.	Condition of Vegetation.	References.
1787 ...	Colebrooke ...	A column of smoke arising from the summit visible 7 leagues off.	......	......	......	... ...	Asiatic Researches, Vol. IV, 1795, p. 397, fig.
1789 ...	Blair ...	In a violent state of eruption, bursting out immense volumes of smoke, and frequently showers of red hot stones, weighing 3 or 4 tons.	32°·17′	1,800	......	Parts remote from the cone covered with withered shrubs and blasted trees.	Report on the Survey of the Andamans, and Asiatic Researches, l. c.
1791 ...	Horsburgh ...	A quantity of very white smoke close to the crater.	......	......	......	... ...	Horsburgh's India Directory, 5th Edn., Vol. II, 1843, p. 55.
1801 ...	Almes ...	... ...	......	......	......	Firewood could be got with difficulty.	
1803 ...	Horsburgh ...	Exploded regularly every 10 minutes, projecting each time a column of black smoke perpendicularly to a great height. In the night a fire of considerable size continued to burn on the east side of the crater.	......	......	......	... ...	
1832 ...	Dr. J. Adam's friend ...	Large volumes of thin white smoke continually issuing.	......	$\frac{1}{2}$ a mile = 2,640 feet	Almost boiling.	Small shrubs scattered about on the S. W. side.	J. A. S. B., Vol. I, 1832, p. 128.
1836 ...	*Von Buch* ...	Account same as in Asiatic Researches, with some variation.	......	1,690 French ft.	......	... ...	Description Physique des Iles Canaries, &c., Paris, 1836, p. 431, Atlas Plate VI.
1840 ...	*Sir C. Lyell** ...	Account founded on Von Buch's.	......	1,848	......	... ...	Principles, 6th Edn., 1840, Vol. II, p. 286, also in 7th Edn.
1843 ...	Lieut. Miller ...	A clear full stream of transparent vapour.	45°	Upwards of 500	......	No vegetation within the amphitheatre, but other parts are well wooded.	Account drawn up by Dr. McClelland, Cal. Jour. Nat. Hist., Vol. III, 1843, p. 422.

1846 ...	"Galathea" ...	... ...	......	......	......	... ...	? Is there any word of this visit.
1848 ...	*Dr. Daubeny* ...	Founded on Blair's account	......	4,000 !	......	... ...	Daubeny on Volcanoes, London, 1848, p. 413.
1851 ...	*Mrs. Somerville* ...	No details ...	......	......	......	... ...	Physical Geography.
1852 ...	*Dr. Buist* ...	Quotes previous accounts ...	......	......	......	... ...	
1852 ...	"Bombay Times" ...	Very active ...	......	......	......	... ...	"Bombay Times," July 1852.
1857 ...	Dr. Liebig ...	Clouds of white vapour issued from fissures near the summit.	40°	980	104°F. ? Almost boiling.	Shrubby patches on the slopes towards the sea.	Zeitschrift der Geollog. Gesselschaft, Vol. X, 1858, p. 302; also in Rec. Govt. of India, XXV, 1859, p. 124; J. A. S. B., XXIX, 1860, p. 1; and in Mouat's Adventures and Researches.
1857 ...	Dr. Playfair and Lieut. Heathcote.	Smoke issued occasionally from a little below the summit.	40°	975	140° F. ?	Not mentioned ...	Rec. Govt. India, XXV, 1859, pp. 121—123.
1862 ...	*G. Poulett Scrope* ...	Account same as that by Dr. Daubeny.	......	4,000	......	... ...	Volcanoes, by G. P. Scroope, M. P., London, 1862, pp. 199 and 468.
1866 ...	Andaman Committee ...	A whitish vapour was evolved from several deep fissures.	40°	980	158°—163°	No trees of any height, but on the slopes and ridges are abundance of shrubs, some rising to 20 feet.	Report on Barren Island, P. A. S. B., October 1866, p. 212.

* For changes in subsequent editions, see page 82.

Authorities whose descriptions are not derived from personal observations in italics.

From the preceding we may gather the following. The volcano has probably not been in violent eruption since the years which closed the last and commenced the present century. The lava-flow which stretches from the entrance open to the sea to the base of the cone was probably poured out during this period, and raised the level of the encircling valley some 40′ above its elevation in 1789, when Blair saw it. He makes no mention of a lava stream in his time. If it did not exist then it cannot—as has been supposed by some—have been instrumental in the formation of the entrance. That this fissure was probably due to other causes we shall presently see.

From Lieutenant Wales' figure it is apparent that no material change has taken place in the general configuration, and as it has been shown that 1,800 feet cannot have been the true height, and about 920 probably was, no great alteration in the level is likely to have taken place.

General appearance of the Island.—Seen from any side but the north-west, Barren Island appears as a nearly flat-topped hill with numerous spurs running down into the sea. From some aspects, however, the top of a central cone with a column of smoke rising from it is discernible.

As the north-west side opens up to view, it is first realised that the island consists of a circular ridge forming a huge amphitheatre, which is broken down at one side for a distance of perhaps 150 yards to the level of the sea. The view obtainable through this entrance discloses a bare cone which rises from the centre of the valley. Except at a sort of shoulder not far from the top, and at two peaks close to the summit, no rocks are seen on this cone, its smooth sides being covered with grey ash and occasional strings of shingle. Towards the top some whitish patches are seen, due to the presence of gypsum mixed with the ash.

The total diameter of the island is, on the authority of Lieutenant Heathcote, 2,970 yards. The circuit of the island, from the time it took us to row round, I estimated at about six miles.

The high encircling ridge is formed of somewhat irregularly deposited layers of lava, ash and conglomerate, which dip away from the centre. A section of these may be seen on the left hand of the gap or entrance, and others at various points on the sea-face, no two of them corresponding exactly in character.

These beds or layers generally dip at angles of 35°—40°, which inclination appears to be continued steadily under the sea, as bottom, except at one place, has not been found with a line of 150 fathoms at $\frac{1}{4}$ of a mile from the shore. This steepness has been unfavourable to the formation of a fringing reef of coral of any magnitude, such as we find surrounding some of the Andaman and Nicobar groups.

The elevation of this outer ridge varies somewhat in places, but it probably nowhere is much in excess of 1,000 feet. Its highest points are towards the south and west.

The appearance presented by the inner scarped face of this amphitheatre is very peculiar. In several places cornice lines mark the position of particular beds, but a purplish grey, or in places brownish, ash spreads over the steep slopes, except towards the south-west and west, where there are some trees and shrubby vegetation. To the north, south and east a few tufts of grass—generally arranged in long vertical lines, the first being a sort of protection to those below it—are the only plants which have managed to establish a footing in the loose ash.

The outer slopes facing the sea are for the most part covered with a luxuriant vegetation, in which large forest trees may be discerned. These latter attract considerable numbers of fruit-eating pigeons (*Carpophaga bicolor*).

From its composition and character, it is evident that this ring of cliffs is the remnant of the original cone which gradually rises from below the sea. Its top and a portion of the

side were, no doubt, blown off by a violent eruption, and the present cone was subsequently formed inside.

For a long time Barren Island was considered by Von Buch and others of his school as a most favourable example of his elevation theory of craters.

The gap or fissure in the surrounding walls bears about north-west-by-west from the centre of the island. It is the only place where an entrance can be obtained to the central valley.

Hot Spring.—Close to the landing place, there is a hot spring which has been mentioned in several of the accounts of the Island. Dr. Playfair found the temperature to exceed 140°, —the limit of his thermometer. Dr. Liebig's thermometer was only graduated up to 104°, but judging from the feel to the hands, he estimated it to be near the boiling point. The Andaman Committee record it at from 158° to 163°. At the time of our visit the highest temperature of the water where it bubbled out of the rocks, close to high watermark, was 130° F. We failed to boil some eggs in it which we had brought with us for the purpose.

The water is perfectly clean and sweet,* and there was no trace of sulphureous vapours. Strange to say, where, though mingled with the sea, it was still too hot for the hand to be retained in it with comfort, there were a number of brilliantly colored fish swimming about.

Facing the landing place is the termination of a flow of lava which extends backwards from this for about a mile to the base of the cone, round which it laps for perhaps $\frac{3}{4}$ of the circumference. The height or thickness of this flow of lava is about 10 feet at first, gradually rising to 50 feet where it emerges from the base of the cone. The upper surface is deeply cleft and covered over with blocks of black cellular lava which rest upon one another in confused piles. Sometimes they are poised so insecurely on one another that it is a matter of some risk to attempt scrambling over them. Towards the base of the flow the rock from its slower cooling is more compact and less cellular. In places it contains white crystals of a mineral resembling leucite. In others it is a true basalt with numerous crystals of olivine.

As pointed out by Dr. Leibig, the older lava seen in the section of the ridge differs from this; it consists of a reddish matrix with crystals of felspar (probably sanidine), olivine, and augite. A somewhat similar rock occurs on Narkondam.

On our way to the central cone from the landing place we at first endeavoured to avoid the rough surface of the lava-flow by keeping on the slope of the gap; but after a short distance the bushes and unevenness of the ground compelled us to strike down on the lava, when we found, to our astonishment, a sort of path which must have been made by the committee sent from Port Blair to report upon the grass.

Arrived at the foot of the cone, we commenced the ascent from the west. The loose ashes and shingle rendered it somewhat toilsome work; and those in front found it difficult to avoid loosening fragments of lava which bounded down the hill in a most unpleasant way for those who were following.

Dr. Liebig appears to have ascended from the north side, where it seems to have been equally difficult.

About $\frac{1}{4}$ of the way from the top there is a shoulder of rock which shows very well in the photograph. This probably marks the position of an old vent. There is a good dea. of firm ground about it.

The summit of the cone is truncated, and contains an oval-shaped depression, one-half of which is partly filled with débris, and the other, some 20 yards in diameter and 50 feet

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* The Andaman Committee do not appear to have realised this fact, as they spent no little time and trouble in excavating a well without finding a trace of water.

deep, has a circular bottom, which is filled with sand. This appears to have been the last crater formed on the island.

The two principal edges of the depression strike to north-west, south-east; they consist of ash permeated with fibrous gypsum (selenite); numerous cracks and fissures occur in this part of the hill, and the ground is hot. On turning over the surface, the sides of these cracks are found to be encrusted with sulphur, resting upon the rugosities of which small detached crystals of the same mineral were not uncommon. From the highest point on the northern edge a thin column of white vapour and sulphureous fumes is slowly poured forth. Even when standing in its midst, the fumes did not prove so irritating a might have been expected.

On the southern side of the crater there is some solid lava *in situ*, and on the west there is a peculiarly shaped mass which forms a conspicuous object from below. Some of the lava here has a reddish matrix and is somewhat vesicular. I also found some basalt, the outer surface of which was weathered into a white crust.

It seems probable that the nucleus of the cone is solid rock to a considerable extent, the ashes seen at the surface being only superficial.

By following water channels when they were to be found, and glissading over the ashes, the return to the base of the cone was effected speedily and without much difficulty.

By a small watch-aneroid supplied with a Vernier scale for feet, the height of the cone is 950 feet; but as one heavy storm of rain had passed, and clouds portended another, I am willing to believe that owing to the atmospheric disturbance the observation was not trustworthy, and that from 975 to 980 feet given by Lieutenant Heathcote, Dr. Liebig and others is the true elevation. The temperature on the top was 83°.

The diameter of the base of the cone is 2,170 feet according to Lieutenant Heathcote. The slopes of the cone incline, according to my observation, at angles varying between 30° and 35°. Blair gave it at 32° 17′, or about the mean of these two. Other observers say 40° to 45°, but the photograph of the cone shows that the former is correct.

Dr. Liebig has discussed the question of the amount of sulphur obtainable on the island. He seems to think the chances of finding a permanent supply very doubtful, but recommends a preliminary trial.

Considering the great expense which keeping up constant communication with the Andamans and the superintendence of convict labour would involve, I cannot see that there is any prospect of the collection and refining of the sulphur being made to pay.

So far as is known, the substance occurs only at the summit of the cone, though, doubtless, if the right places could be found, it does also occur lower down. But in such places, it could only be as an old deposit which, on being worked out, would not be replaced again.

On the summit the deposit, so far as I could see, proceeds very slowly, certainly not with sufficient rapidity to keep laborers constantly employed.

NARKONDAM, Lat. 13° 24′; Long. 94° 12′.

History and previous notices.—So little has been published regarding this island that a few lines will suffice to dispose of all that has ever been recorded regarding it.

In 1795 it was passed by Colonel Symes* when on his voyage to Rangoon, whence he started on his embassy to Ava. He speaks of it as "a barren rock rising abruptly out of the sea and seemingly destitute of vegetation."

* Embassy to Ava, Vol. I, 1827, p. 167.

Dr. McClelland, writing in 1838,* says: "It is a volcanic cone raised to the height of 7,800 feet. He gives a sketch showing the figure of the cone, the upper part of which is quite naked, presenting lines such as were doubtless formed by lava currents descending from the crater to the base, which last is covered with vegetation." No soundings are to be found at the distance of half a mile from the shore. This account is reproduced by Mrs. Somerville, Dr. Daubeny, Dr. Buist and Mr. Scrope.

Horsburgh† says—Narkondam may be seen about 14 or 15 leagues from the deck, and appears in the form of a cone or pyramid with its summit broken off; it is bold and safe to approach all round.

Mr. S. Kurz, in his report on the vegetation of the Andaman Islands, writes: "Narkondam Island has an extinct volcano remarkable for the great height of its cone, being twice as high as its outer wall. Owing to the great height of the cone (perhaps 2,000 feet) in proportion to the surrounding wall, this island must have sunk very much, or the volcano must have been formed from a considerable depth in the sea." Mr. Kurz gives an outline sketch of the island as it appeared to him from a distance of 20 miles.

In a paper on the geology of the neighbourhood of Port Blair, I made a few remarks on the appearance of Narkondam as seen from a few miles distance. In it I accepted the height of the cone, 2,150, given on the chart, as authentic. This, it will be seen by the sequel, I do not now adopt as correct. In the *Indian Observer* for the 10th of May a short account of the present visit will be found.

Viewed from the north-west at a distance of about 4 or 5 miles the island of Narkondam appears to consist of a tolerably regular cone which rises from an interrupted ring of irregularly piled masses. The apex is somewhat truncated, but has three distinct peaks. On the occasion in 1869 when I first saw the island a dense mass of cloud rested on the top, and I was unable to make out the character of the summit. But when subsequently seen, it was observed that there were three peaks as represented in the sketches published by Mr. Kurz and Dr. McClelland. The upper parts of the cone and the sides for more than half way down are deeply furrowed by ravines, and what appears to be a low scrub jungle spreads uniformly over the island save upon some vertical scarped faces.

With the general consent of those who have seen it, the conical form has been accepted as a proof of the volcanic character of the island. Dr. McClelland, as noted above, speaks of the lined appearance being "doubtless formed by lava currents descending from the crater to the base." These lines are, however, simply the result of erosion, and mark the position of the watercourses.

The elevation of the summit of the cone has been variously estimated at from 700 to 2,150 feet. Since however, according to Horsburgh, the island first becomes visible from the deck of a steamer at a distance of from 14 to 15 leagues; it is probable that about 1,300 feet would be nearer the true altitude, and such indeed, judging by the eye, appears to be a very fair estimate.

On the occasion of our visit we landed in a small bay on the north-west side of the island. At about 100 yards distance from the beach the water became so shoal that we were compelled to land on a raft. We soon found that the jungle which, in the distant view, appeared to consist mainly of low scrub was really composed of large forest trees with a thick undergrowth. So dense was this, just above high water mark, that at first it seemed probable that it would be impossible to penetrate it. Added to the natural density of the jungle, another obstacle was presented by the prostrate condition of many of the trees, which in their fall had carried

* On the difference of level in Indian Coal-fields, J. A. S. B. VII. Also in the Coal Committee's report, and in Corbyn's Indian Review.

† Indian Directory, 5th Ed., Vol. II, 1843, p. 55.

down tangled masses of creepers and the lower vegetation. It soon became apparent that at no very distant period a violent hurricane or cyclone must have swept across the island. An entrance was at last found, and for three hours, cutting our way and making constant detours to avoid fallen trees, we endeavoured to force onwards to the summit, but were at length compelled to give up all hope of succeeding and returned to the beach. Further evidence of the hurricane was there afforded by numerous fragments of a wreck which had been thrown up on the sand. Subsequently this storm was identified with one which took place on the 26th of October 1872, and did much damage in the Cocos Islands and other parts of the Bay.

The only rock seen where we landed was a conglomerate, or boulder bed some 50 feet thick. The boulders consisted of a trachytic porphyry which contained sanidine, augite, and mica in grey or pinkish matrices. We discovered no evidence whatever of recent lava or basalt occurring, though either or both may exist, as our observations were confined to one small bay.

Notwithstanding the luxuriance of the jungle which included species of Ficus, Palms (Caryota), Acasia, Calosanthes, &c., no fresh water was discovered.

Much remains to be done in the exploration of this most interesting volcanic island. It is particularly desirable to ascertain whether there is really a crater at the summit, and whether there are any traces of recent lavas.

Future visitors would do well to provide themselves with some wood-cutters. They should land near the northern spur, and getting then on the steady rise, they will probably find no insuperable obstacle on their way up.

STRAY NOTES ON THE METALLIFEROUS RESOURCES OF BRITISH BURMAH, *by* W. THEOBALD, *Geological Survey of India.*

Though little that can, strictly speaking, be called precise information respecting the mineral wealth of Burmah exists, either as regards the value or extent of its presumed mineral sites, yet it may be not without interest to give a brief sketch of what stands recorded on the subject, leaving for future investigators the task of sifting these statements and determining the importance in an economic point of view of each separate locality.

A general impression is undoubtedly prevalent that considerable metalliferous resources exist in Martaban and Tenasserim, and that it only requires a thorough examination of these districts to establish the fact in a manner sufficiently clear and precise to tempt the European speculator and capitalist into the field, and originate a new and thriving branch of industry which would soon prove of great value to the province. Unfortunately, nothing very tangible is known, though the matter has never been quite lost sight of, and has attracted the attention of district officers, among whom Mr. O'Riley in Martaban, and Major Malcolm Lloyd in Tounghoo, may be prominently mentioned. A serious cause, however, of error, and of a too favourable view being taken of the productiveness of a new mineral locality, lies in the fact that undue importance is too commonly attached to the result of an analysis of a small specimen, which in reality affords no criterion whatever of the value of the discovery in an economic point of view, since the actual richness of the ore is perhaps the least important element to be considered; the two far more important points for consideration being the amount of ore procurable, and its position as regards water carriage, and other facilities for its extraction and reduction. Of course, all other conditions being equal, a rich ore is more valuable than a poor one; but the mere analysis of a small specimen of ore, how rich soever it prove, is no criterion whatever of its economic value, or whether it can be profitably worked. A reduced copy of Mr. O'Riley's map of Martaban, showing mineral sites, is published herewith for general convenience.

The only ores which need be noticed for practical purposes are those of iron, tin, lead, copper, antimony, none of which, save iron, are known to occur West of the Sittoung, but are confined to the belt of country running up from the British boundary on the Pakchan creek in Latitude 10° North to the frontier in Latitude 19° 30′. This tract of country differs essentially from the ground West of the Sittoung, the former being composed of several groups of beds of Palæozoic age, both altered and unaltered, together with metamorphic rocks seemingly azoic, the whole being traversed by granite and elvan dykes and pierced by numerous hot springs, whilst the latter is wholly made up of Secondary and Tertiary rocks, the newer greatly predominating; and wherein intrusive rocks are next to unknown. Physically also, and as regards climate, the country East of the Sittoung differs no less from that West of the river, than it does geologically. Martaban is essentially a mountainous country with lofty chains stretching in a north-north-west direction, some of whose peaks rise to 6,000 or 8,000 feet, and would afford some of the most charming sanitaria in India were they only a little more accessible to those who might be benefited by a resort to them. As a result of the geological constitution of the ground, copious and perennial springs abound and give rise to a charming verdure and coolness even over the lower elevations to which I know of no parallel elsewhere; and though said to be unhealthy (how truly I know not), the pine forests of the Youzalin are among the coolest and pleasantest districts, as far as temperature goes, which India can offer. It is this very district which, according to common report, teems with mineral wealth; but a most unfortunate drawback to its proper investigation is its wildness and want of population, which means also want of roads of any sort, and difficulty in the matter of supplies, not to allude to risk of sickness (a common concomitant, among camp-followers at least, on a greatly reduced temperature), and the attack of plundering bands, which find a sort of happy hunting ground along all this difficult wild country adjoining on the Karen-ni and Zimmay territories; traders and travellers being the special victims of these freebooters. The regular dacoit, moreover, is not the only 'conveyancer' to be dreaded; as it was but little more than a year ago that the entire police guard escorting some treasure, belonging to a trader, appropriated the money and then humourously stepped across the frontier with their arms, accoutrements and all as they stood, heedless of the feelings of disappointment, if not shame, which their doing so must have caused their comrades whom they left behind.

Iron.—Excellent ores of this metal occur both in Pegu, Martaban and Tenasserim, and in former days were smelted by the Burmese, but the manufacture is no longer to my knowledge carried on in British Burmah, though iron is still made in Upper Burmah, near Puppadoung, from ores similar to that formerly used in the Prome district. In Pegu (Eastern Prome) the ore occurs in the form of concretions of an earthy hydrated peroxide disseminated through the newer Tertiary beds which are there so extensively developed, and of which an account is given in the Records of the Geological Survey of India for 1869, page 83. East of the Sittoung the ore usually met with is the magnetic, a mixture of the protoxide and peroxide, often occurring in thick beds or lodes, and a valuable ore for smelting. Specular iron also occurs as an integral constituent mineral in some of the crystalline schists, and has from its brilliancy been mistaken for galena.

Mr. O'Riley remarks that "iron occurs abundantly in the lower ranges of the hills to the east of this station" (Shuay Ghyin), and the same valuable ore, the magnetic oxide, is known also to occur in Tavoy; but these deposits will probably not prove remunerative to work for many years, or till the difficulties which of late have threatened mining industry in England shall have become more weighty and confirmed.

Tin.—This metal is unquestionably the most important commercially of any produced within our Eastern possessions. Though beyond some workings near Malee-wan on the Pakchan river, near Latitude 10° 10′ North, the ore is nowhere systematically worked

on a large scale within British territory. South of the Pakchan stream the richness of the tin washings derived from the degradation of a stanniferous granite, in which the tinstone occurs as one of the integral constituents of the rock, is well known, and reference may be made for information connected with this question to a report of Dr. Oldham, published in Selections from the Records of the Government of India, No. 10, page 56.

But the fact of most interest as regards British Burmah is, that this stanniferous granite and its associated deposits of stanniferous gravel, stretches up as far north as the parallel of Tounghoo, east of which station on the eastern slopes of the Pounglong Range, the metal has from time immemorial been worked by the Karen-ni, or Red Karen tribes within whose territory it lies. Tin ore has long been known to occur in the streams discharging into the Henzai basin in Latitude 14° 40′ and also at "Chando near Palouk, about two days journey from the sea, halfway between Mergui and Tavoy" (*vide* Gleanings of Science, vol. I, page 143); but how far to the north of Tounghoo this stanniferous granite continues, is not known, though as likely as not for 500 miles or more. As the tin works above alluded to at Kamapew, are some 2 miles beyond British territory, it is very important that Mr. O'Riley has traced the ore across the range of hills into the drainage basin of the Sittoung; and to Mr. O'Riley belongs the credit of having first drawn attention to the above fact. His words are as follow: "Tin: of the existence of this metal within the area of this district, I was convinced from having traced the stanniferous formations of the "Kaimapyu" which fall into the Salween, across the ranges of hills, whose drainage flows into the Sittang valley, and on forwarding to the Karens specimens and instructions, I was enabled to procure the specimens A. B." Of course Mr. O'Riley may have been misinformed, and the specimens in question may in reality have come from the Eastern, Salween valley, side of the hills and not from the British or Sittoung side; but as Mr. O'Riley was fully aware of the importance of this point, I am prepared to believe his statement in this particular to be correct. Mr. O'Riley goes on to add: "The specimen A exists in the hills north of the Youkthwah river, within the Tounghoo district, and the other, in the head waters of the main stream." I myself received some corroborative testimony to the same effect, when examining some hot springs in the lower part of the Youkthwah river; but nothing is actually known of the precise locality where the ore exists, nor can be till some one is specially deputed to examine the question. Major Malcolm Lloyd, Deputy Commissioner of Tounghoo, has much interested himself with the resources of his district, and has furnished me with the following itinary from Tounghoo to Kay-mah-pew, from which the difficult nature of the intervening country may be inferred, since the actual distance from Tounghoo is probably not much over 45 miles. On the last march the British boundary is crossed about the fourth mile.

Route from Tounghoo to Kay-mah-pew.

	Miles.
Tounghoo to Khoung-nouk-kwa	18
Khoung-nouk-kwa to Paylawa	8
Paylawa to Bogallee	8
Bogallee to Nothedoe	10
Nothedoe to Mobwaydo	10
Mobwaydo to Ivoobo	6
Ivoobo to Kadowboe	16
Kadowboe to Kay-mah-pew	15
	91

The current price of tin ore in Tounghoo used not to exceed, as I am informed by W. Usher, Esq., Rs. 185 the hundred viss (about 375 lbs.); but latterly the price has risen to Rs. 205 and even to Rs. 230 for choice lots, the same realizing Rs. 250 in Rangoon. As the carriage from the mines to Tounghoo is at present wholly by coolies, it seems desirable

to ascertain if no alternative route can be devised by the Salween to Moulmein, making use of water carriage for part of the way.

GALENA.—This ore is known to exist in numerous spots in Martaban and Tenasserim, and is usually argéntiferous to the extent on an average of 12 ounces of silver per ton of lead, taking as a guide the first six analyses of the subjoined table. In this respect the galena from Bamo and Upper Burmah is far richer, the mean of three samples from Bamo, giving 78 oz. 17 dwts. of silver to the ton of lead, the poorest yielding 58, and the richest 104 ozs.

Table exhibiting the amount of silver in ounces per ton of lead, from samples of Galena from various parts of Burmah.

						oz.	dwts.	gr.
1.	Galena	Martaban	...	...	...	5	8	0
2.	Do.	do.	...	...	...	5	14	0
3.	Do.	do.	...	...	...	9	0	0
4.	Do.	Tavoy	...	...	...	16	7	19
5.	Do.	Moulmein	...	...	...	19	5	14
6.	Do.	Tounghoo	...	...	...	20	8	7
7.	Do.	Bamo	...	...	..	58	14	8
8.	Do.	Bamo (Ponsee)	...	...	...	73	10	0
9.	Do.	Bamo (Kyet-yo)	...	...	...	104	10	16

Nine localities where galena occurs are marked in the sketch map of Martaban by Mr. O'Riley, ranged generally on a north-north-west line of bearing, coinciding with the general direction of the hill ranges, and extending over a line of country some 90 miles in length. Mr. O'Riley describes the ore as occurring in the mountain-limestone formation of the district, which is that also to which the magnificent and picturesque limestone hills near Moulmein, and along the Salween belong, but he does not say if the ore occurs disseminated in the rock, or in the form of a true mineral vein or lode. From what I have remarked on the north-east of Tounghoo, at the spot whence Major Lloyd procured his galena, I am inclined to think that it may occur on both ways, as it is there rather doubtful if there is a true vein, whilst on the Salween valley, the accounts would certainly suggest the existence of lodes.

I am sorry I cannot give any account of the attempts which have been made by private parties to work the lead and silver of Martaban, but much reticence is naturally observed on such a subject, either from a feeling of distrust or of vexation at the unfortunate results of crude attempts and hasty speculation. Nothing that has as yet been done, however, can be considered as conclusive either for or against the practicability of bringing these ores into the market. At present the wild state of the country seems to me the main obstacle to arriving at a satisfactory conclusion on this subject, from the sparseness of population and consequent inability for any one to properly scrutinize these impenetrably clad hills.

COPPER.—Four specimens of copper ore were procured by M. O'Riley, three of them from the same localities as the galena, one of them from the hills east of the Sittoung River, and all consisting of "the ordinary copper pyrites, both arsenical and combined with sulphur and iron." I have not myself been so fortunate as to procure any undoubtedly Martaban copper ore, save pieces brought to me exhibiting traces of that metal in the form of green carbonate associated with iron or lead ore, to the extent, and no more, of implying the presence of a small portion of the more valuable metal in the mass. Not far from Moulmein on the Ataran River, I have seen heaps of slag which some believed to be old copper workings; but an analysis shows that the slag does not contain so much as a trace of copper, and indicates merely the former presence of iron works, abandoned before the memory of the existing inhabitants.

An extremely interesting specimen of copper ore of a somewhat novel composition was procured by M. O'Riley from some spot on the Yoonzalin River, said to be accessible for boats.

Mr. Waldie, who analysed it, describes it as a new mineral species under the name O'Rileyite, in the Proceedings of the Asiatic Society of Bengal for 1870, page 279. Two analyses of the samples were made as below, the first being that of a sample forwarded on the 24th July, the second, which differs slightly, a sample forwarded subsequently:—

Copper	17·000
Silver	0·096
Iron	36·470
Antimony	1·150
Arsenic	32·700
Sulphur	1·360
Earthy matter	0·560
Deficiency and loss	10·664
	100·00

The silver in the above sample is equal to $31\frac{1}{3}$ ounces troy per ton. The large amount of loss, however, (presumed to be mainly arsenic) was unsatisfactory, and Mr. Waldie, therefore, made a careful analysis of a second sample of the same mineral, forwarded by M. O'Riley on the 10th of October, with the following results:—

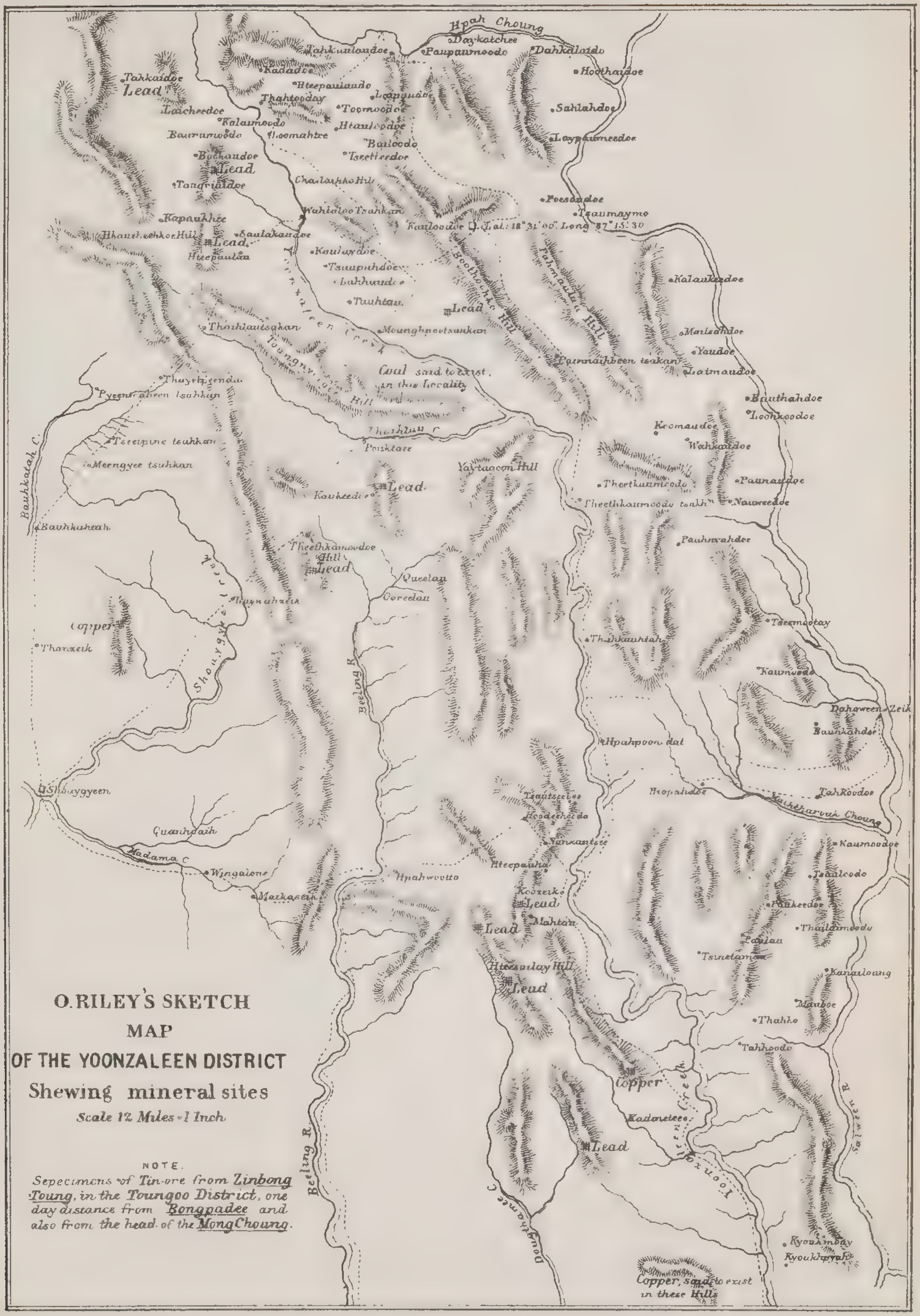
Specific gravity: In small pieces 7·343: In powder 7·428.

Copper	12·13	
Iron	42·12	
Arsenic	38·45	
Antimony	0·54	
Earthy matter	0·12	
Oxide of copper	1·21	Soluble in dilute hydrochloric acid.
" lead	1·89	
Arsenious acid	1·12	
Protoxide iron	1·97	
Loss	0·45	
	100·00	

Indications of the presence of copper, in the shape of stains of the green carbonate, are also occasionally met with; one such being recorded in the Geological Notes by Captain W. Foley, in the *Botoung* hills, 90 miles north-north-east from Moulmein (Maulamgeng); his words are: " Silver ore is said to exist in a limestone rock at this place; and judging from the numerous excavations that had been made by those in pursuit of the precious metal, no little labour has been used in the endeavour to discover it. I had neither time nor opportunity for ascertaining whether silver ore *does* so exist. Pieces of *copper green, iron pyrites,* and *lead ore* deemed useless and cast aside by those in pursuit of silver were strewed about the place, and for the first time, in this part of the world, I observed *anthracite* dispersed in thin seams through the limestone rock."

From this interesting passage, I should infer that extensive diggings for galena had been made here, as in a note the rejected lead ore is said to be the " *arseniate,*" possibly identical with phosphate of lead containing arsenic, which has recently been received in the laboratory of the Geological Survey for analysis from the Martaban district.

ANTIMONY.—Antimony occurs associated with galena in Martaban, but is nowhere worked in British territory. Metallic antimony, however, is imported to a small extent from the Shan States, and is probably used as an ingredient in the alloys of copper and silver which are worked up for ornaments by the Shans, who excel in all sorts of metal work. Antimony does not seem to receive much attention as a metal, though the powdered sulphide is largely used throughout the East as a collyrium under the name of *soormah,* the application of which along the eyelid, in the shape of a fine black powder, is supposed to enlarge the


O. RILEY'S SKETCH
MAP
OF THE YOONZALEEN DISTRICT
Shewing mineral sites
Scale 12 Miles = 1 Inch
NOTE.
Sepecimens of Tin-ore from Zinbong Toung, in the Toungoo District, one day distance from Bongpadee and also from the head of the Mong Choung.
Hpah Choung
Daykatchee
Dahkaloido
Hoothaidoe
Sahlahdoe
Lead
Coal said to exist in this locality
Yaytagoon Hill
Copper
Shouygyeen
Madama C.
Wingaloon
Beeling R.
Hpahpoon dat
Copper
Lead
Copper, said to exist in these Hills
Kyouk-mbay
Salween R.
Bauhkalah C.
Kalaukedoe
Dahoween Zeik
Kaumoodoe
Thailaimoodo
Kanauloang
Tahkoodo

apparent size of the eye and add to its lustre and beauty. In India at least, however, no discrimination seems to be made between the sulphide of antimony and ordinary galena, which goes also by the name of *soormah.*

GOLD.—Though of slight economic importance, gold occurs in most parts of Burmah, but is very little worked within British territory, which I attribute to the higher and more certain remuneration there obtainable for agricultural or other labor; and gold working is, therefore, pursued mainly in bad seasons, or as an exceptional means of industry taken up merely now and again.

I am not aware of platina having been discovered in British Burmah, but as it is known in Upper Burmah under the name of Shwaybeen (white gold), it probably, I think, will be found in Pegu also, but perhaps in too fine a state of division to be independently separated.

In Volume III of the Gleanings of Science a very interesting analysis of a platina 'button' from Ava is given by J. Prinsep, which I here transcribe in proof of the actual occurrence of the metal, which might also be doubted:—

Platina	25
Gold	5
Iridium and osmium	40
Iron	10
Arsenic and lead	20
	100

The sole use the metal is put to is as an alloy, the only form of course in which the Burmese are capable of manipulating it. The proportion of the metals iridium and osmium is remarkable; and additional samples from Bamo are much wanted for analysis, but such are scarcely procurable save on the spot.

An impure earthy cobalt containing manganese was many years since procured by myself near Henzai, but I could learn no particulars beyond the above rather vague one of locality. It was a nodular mass of a black color enveloped in white clay, not more than an ounce in weight altogether.

The above remarks are all that I need offer on the subject, my intention being solely to point out in a brief manner what previous observers have recorded on the subject of the metalliferous wealth of Burmah.

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